

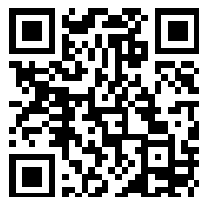


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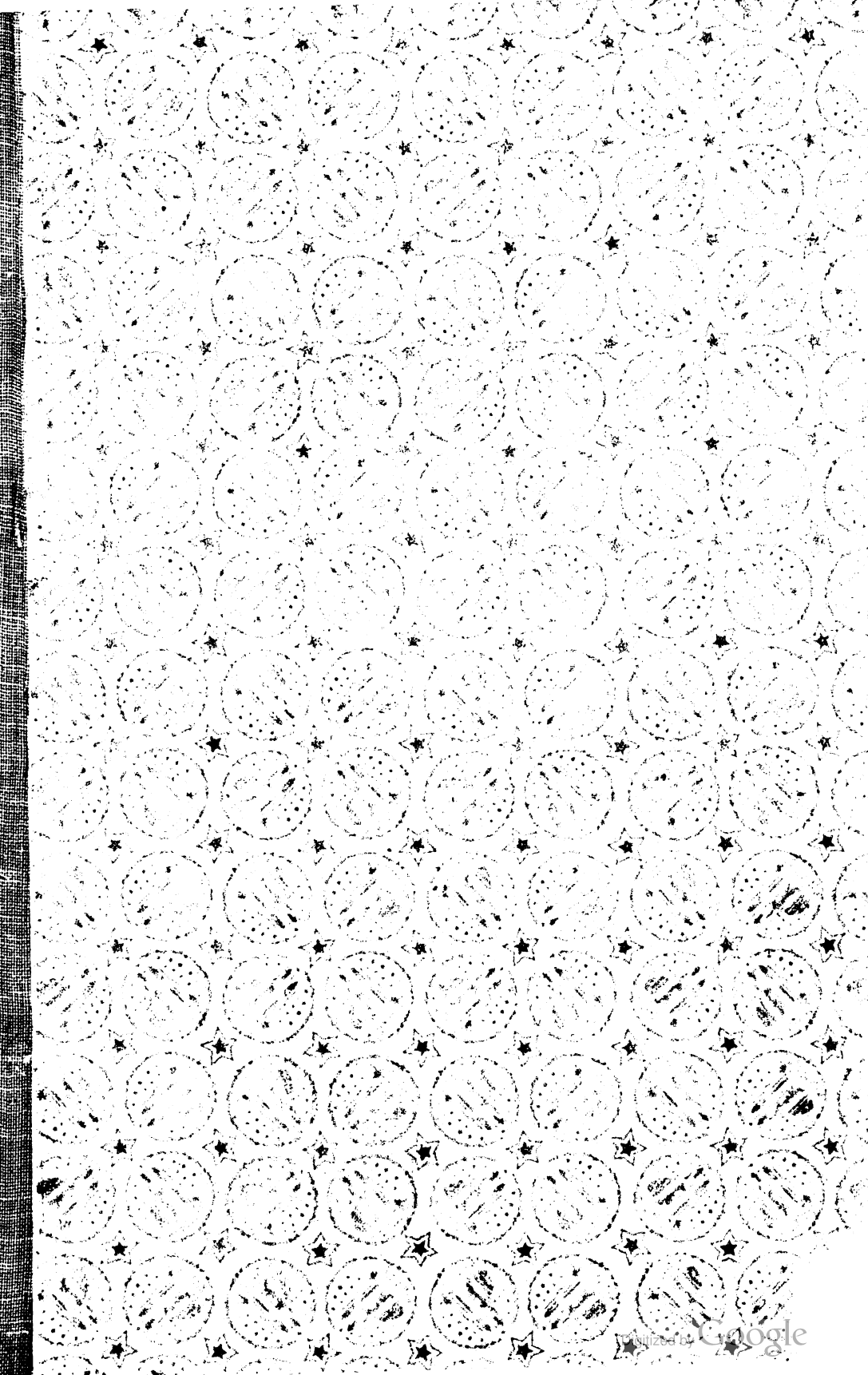




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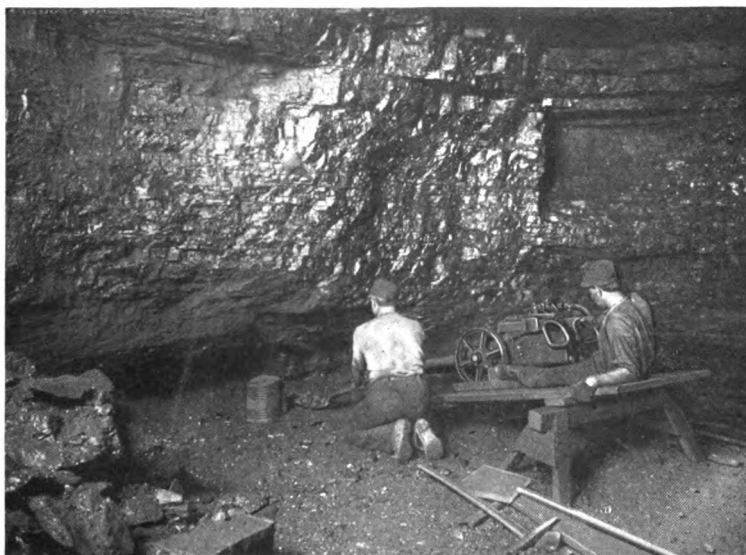


# MINE AND QUARRY

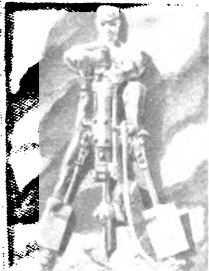
VOL. VI. No. 1

AUGUST, 1911

WHOLE No. 19



MINING ILLINOIS COAL



MINING COAL AT COLLINSVILLE,  
ILLINOIS

DAMMING THE MISSISSIPPI

QUARRYING WITH HAMMER DRILLS



PUBLISHED  
BY THE

SULLIVAN MACHINERY CO.

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# MINE AND QUARRY

Vol. VI, No. 1

AUGUST, 1911

Whole No. 19

*A Quarterly Bulletin of News for Superintendents,  
Managers, Engineers and Contractors.*

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## A NEW SHAFT RECORD

Reports from Globe, Arizona, indicate that a new record for rapid shaft sinking has been set for this country, if not for the world.

During the thirty days elapsed between April 21st and May 21st, The Live Oak Development Co. sunk its No. 2 shaft vertically 205½ feet and the miners did their own timbering, in addition. This is a double compartment shaft 5 x 4½ feet in size. Three shifts, of four men each, were worked per 24 hour day. All drilling was done with two US 2½-inch Sullivan rock drills, driven by air furnished by a class WB-2 straight line, two stage, Sullivan Air Compressor, with 16 x 16-inch steam cylinders, and 18 and 11 x 16 inch air cylinders.

Shafts have been sunk farther than this in South Africa in thirty days' time, notably that of the Van Ryn Deep in July and August, 1910, 279 feet. This shaft was 20 x 7½ feet in size, but was comparatively flat, being driven at an angle of only 22 degrees from the horizontal. This work was done with six 3¼-inch drills.

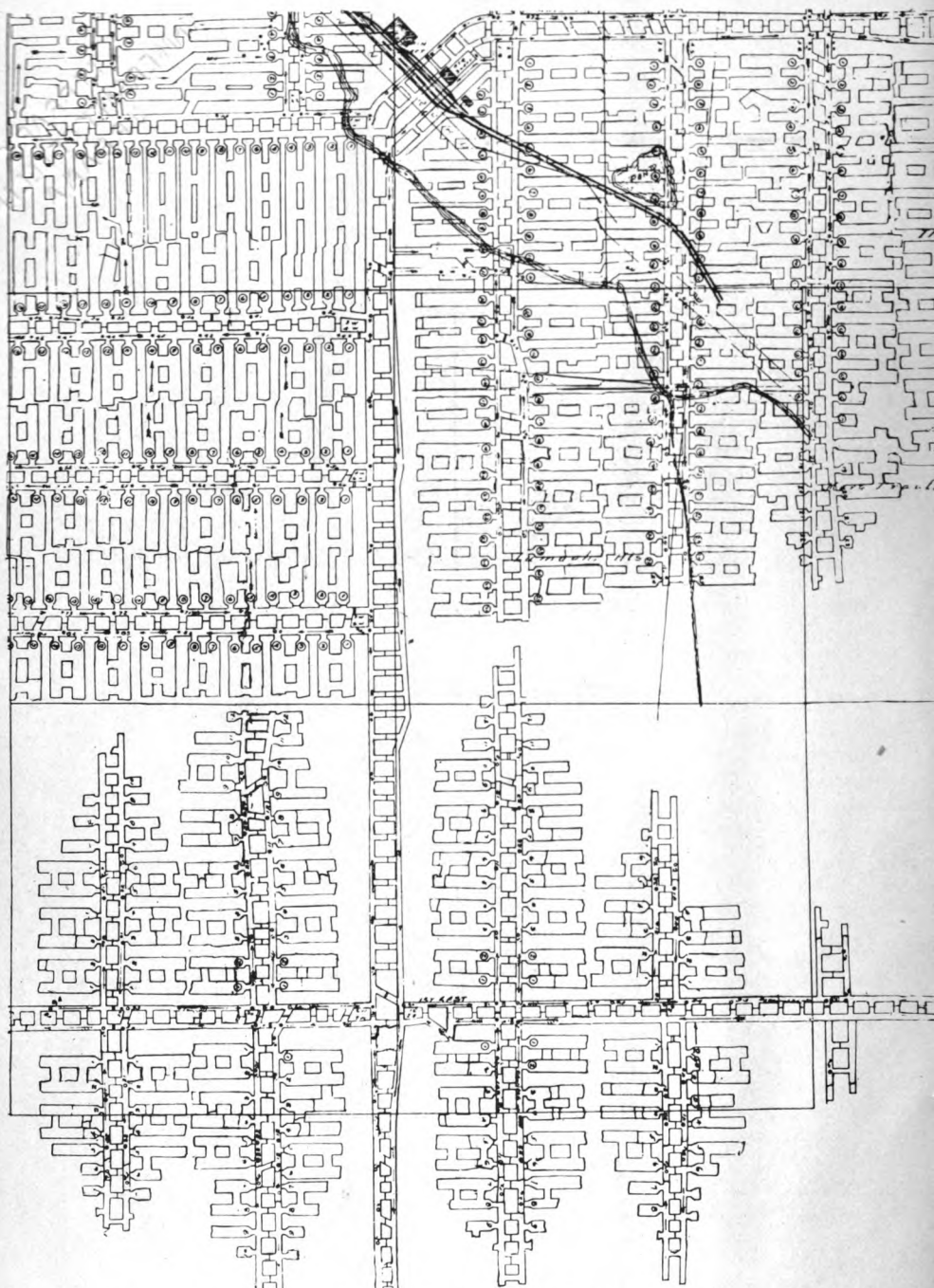
From May 1st to May 31st, the Live Oak Shaft was driven 183 feet.

Nova Scotia is one of the few localities in which it is possible to institute a fair comparison between the work of the diamond core drill and core drills of the calyx or shot type, as both are used under the same conditions and in the same formations.

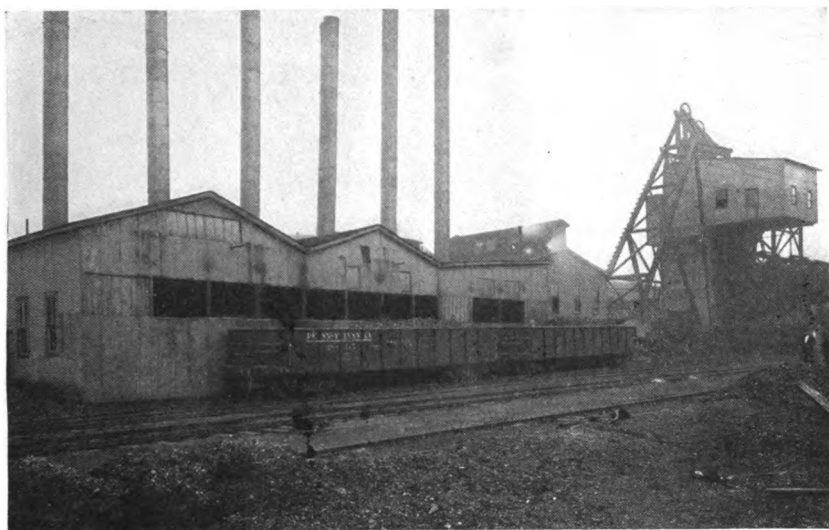
On another page appears such a comparison, based on the drilling done in 1910. The fact that drilling with the diamond core machine was so much more economical than with the calyx pattern, in spite of the fact that the former did between six and seven times as much work as the latter, should be carefully noted by those who have the impression that the high cost of diamonds is an argument for adopting the calyx pattern of drill.

In 1909 the cost per foot of shot used in the calyx machines was \$.055; in 1910, \$.02. In 1909, the cost per foot of diamonds or carbon for the diamond drills was \$.037; in 1910, \$.067, figures to which due weight should be given in considering the choice of an outfit. The cost of labor in 1910 for the shot drill averaged 32½ cents per foot, for the diamond drill, 25 cents per foot.

The report of the Nova Scotia Department of Mines further says, "The 1,500-feet two-inch core drill purchased last year has been in almost continuous use, boring a total of 2,061 feet. This machine has given entire satisfaction, and with the use of a special core barrel a high percentage of core from coal seams passed through has been recovered."



Workings of a part of No. 2 Mine, Lumaghi Coal Co. The upper half shows the cross entry system formerly employed the lower portion shows how the panel system is being developed



Lumaghi Coal Co., top works, No. 2 Mine

### MINING COAL AT COLLINSVILLE, ILLINOIS

#### MINING MACHINES AND THE PANEL SYSTEM SECURE ECONOMICAL PRODUCTION AND SAFETY

By M. C. MITCHELL<sup>1</sup>

Coal has been mined in and about Collinsville, in Madison County, Illinois, since 1870. In the early days it was produced by hand pick, and later some machines were employed. But as the demand for coal and the shortage of labor increased, the practice of shooting from the solid became general. While this increased the output per man it was found to be dangerous and destructive, decreasing the percentage of lump coal and raising mining costs.

About 1900, the Lumaghi Coal Company, whose main offices are in the Equitable Building, St. Louis, tested and finally purchased about 16,000 acres of coal land on Cantine Creek, two miles east of Collinsville, on a spur of the Vandalia Railroad.

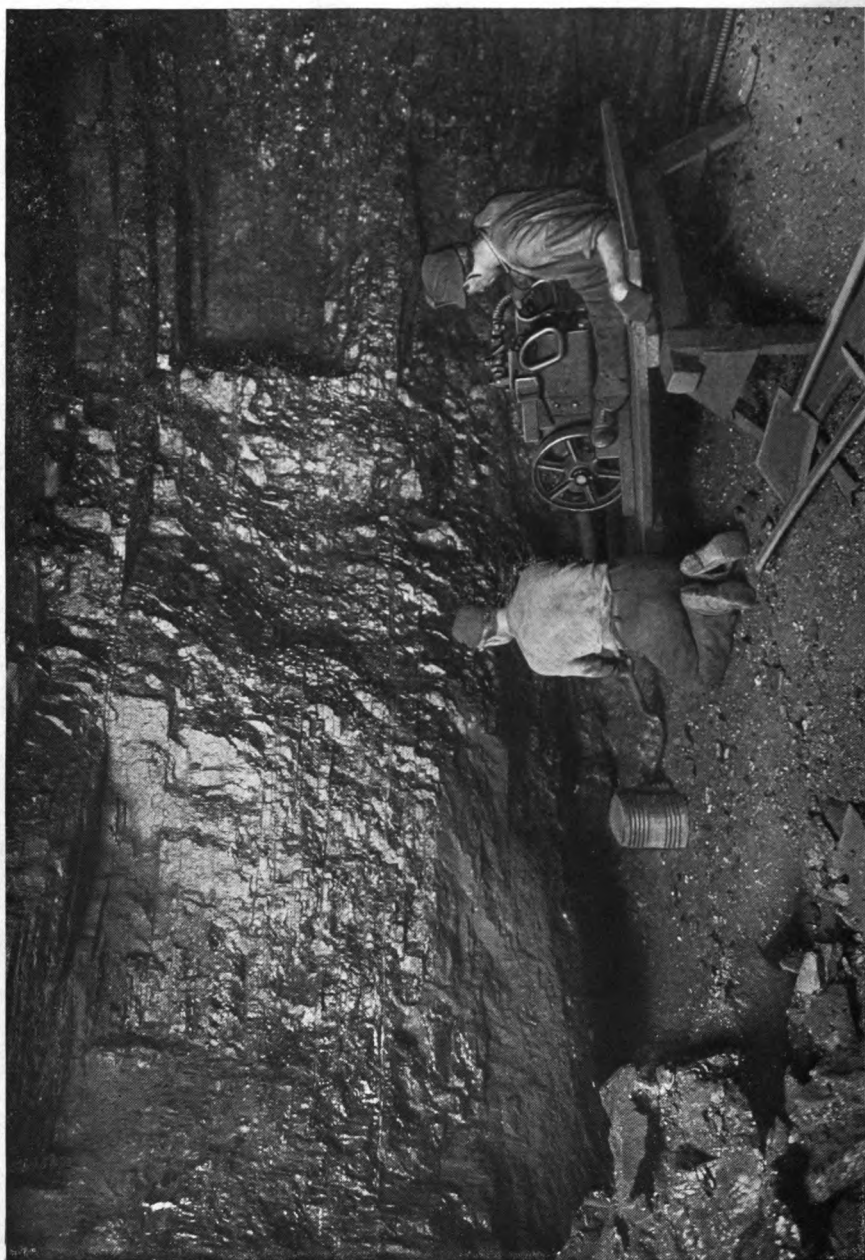
<sup>1</sup> St. Louis, Missouri.

#### DIAMOND DRILL TESTS

Borings made with a Sullivan diamond drill, removing a two-inch core, proved the existence of an eight-foot seam, 200 feet from the surface. In this seam, geologically known as No. 6, the coal is hard and firm, with a black slate roof six feet thick and a fire-clay bottom. It lies practically level, and is uniform in quality throughout the area tested. It is used for both steam and domestic purposes.

#### SINKING TO THE COAL

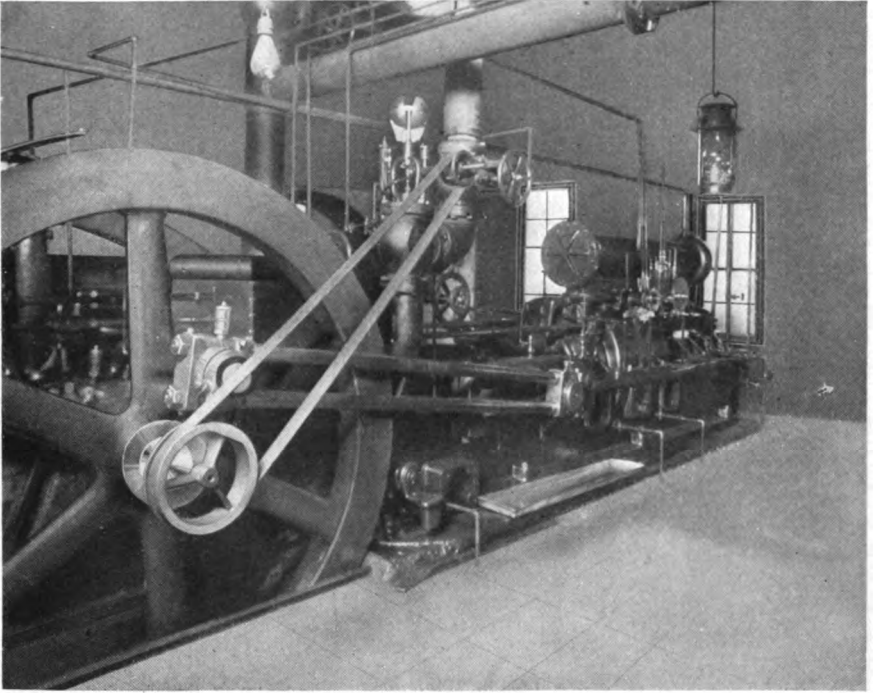
A hoisting shaft, 8 x 17 feet in the clear, and an air shaft containing a 6 x 6-foot air compartment and a 4 x 6-foot stairway, were next sunk, with Sullivan "UB" 2½-inch steam drills. The large shaft required 60 days and the air shaft 47 days to reach the coal at a depth of 200 feet.



Sullivan Pick Machine, Lumaghi No. 2 Mine



Sullivan Electric Continuous Coal Cutter crossing the face in Lumaghi No. 2 Mine



Sullivan "WB-2" Straight Line Air Compressor, Lumaghi No. 2 Mine

#### DEVELOPING WITH MACHINES

It was decided to open up the mine to a capacity of 1,000 tons per day with machines, and then use the machines for entry work only, shooting from the solid in the rooms. The cross entry system was adopted and a plant installed which included ten Sullivan class 5 pick machines of the piston valve pattern, and a duplex single stage compressor. These punchers weigh 825 pounds and cut to a depth of  $5\frac{1}{2}$  feet under the coal. One of them is shown at work on page 516. The main east and west entries were driven ten feet wide with these machines at an average speed of 18 feet per day of two shifts, for each entry. Shooting was allowed at any time of the day, to permit rapid progress.

After the mine had reached the capacity

above named, the question of shooting from the solid in rooms was raised. The grade of coal produced by the machines had proved so much better than that secured by hand work that the management decided to continue the entire mine on a machine basis. Accordingly a second air compressor was installed, of the Sullivan "WB-2" straight line, two-stage pattern, together with additional Sullivan pick machines, of which 26 are now in use. The Sullivan compressor, which has a simple steam cylinder, with balanced valves and hand adjusted cut-off, proved so much more economical of steam than their old duplex compressor, that it is kept running constantly, the smaller machine being operated from time to time to handle the peak load.

#### PRODUCTION PER MACHINE

In 1910, this mine produced 461,103 tons, in 217 working days, making an average of 2,124 tons per day. Each machine of the 29 in operation that year cut an average of 15,900 tons, or about 73 tons per machine per day. It is reasonable to assume that all of these machines did not work every working day; therefore the actual production per machine per day is in excess of the above.

It may be noted that 4,054 kegs of powder were required to shoot this tonnage, or 114 tons per keg of 25 pounds. In a neighboring mine, where solid shooting was in vogue, and the tonnage nearly the same, only 26 tons were produced by one keg of powder. The fact that the coal seam in the second mine was one foot thinner than at the Lumaghi property does not explain the tremendous difference (more than four to one) in the amount of powder needed when the coal was mined on the solid and when undercut. The price which the coal from this mine brought during the above year was on an average of ten cents a ton higher than that secured for coal in neighboring mines on a "solid" basis, indicating the superior character of the coal produced by machines.

#### SYSTEM OF MINING

About two years ago the company changed its plan of operation in this mine, known as the No. 2, to the panel system. This method is shown in the accompanying sketch. The main entries are driven 10 feet wide and the air courses 20 feet, with a 50-foot pillar between. Panel entries and air courses, also 10 and 20 feet wide, are turned at right angles to the main entry, on 2,500 foot centers. The unusual width of the air courses permits the roof slate to be dropped, leaving a rock top 45 feet in thickness. The pillar between the panel entry and air course is 45 feet thick; stub entries are driven 20 feet wide, with a 40-foot barrier pillar, and are 1,200 feet, center

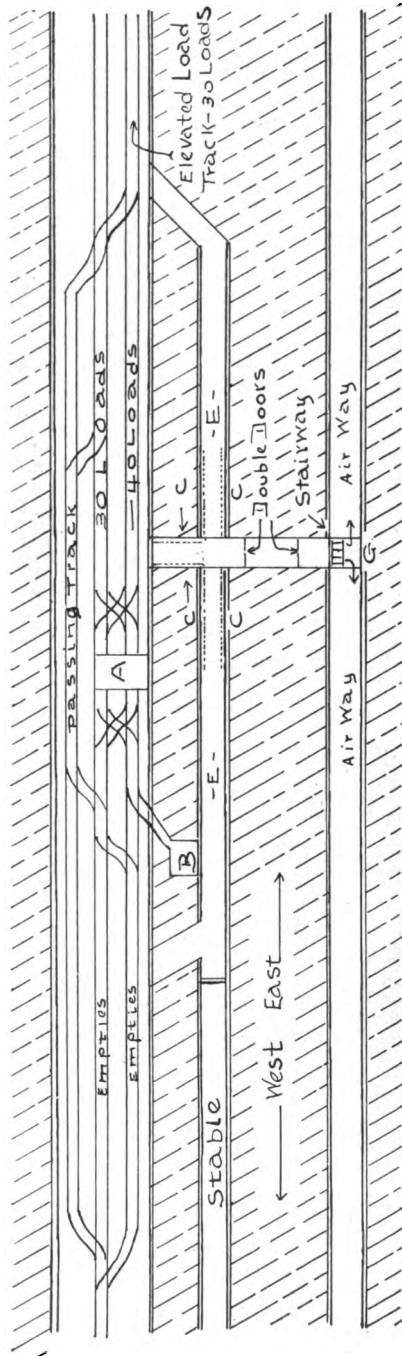
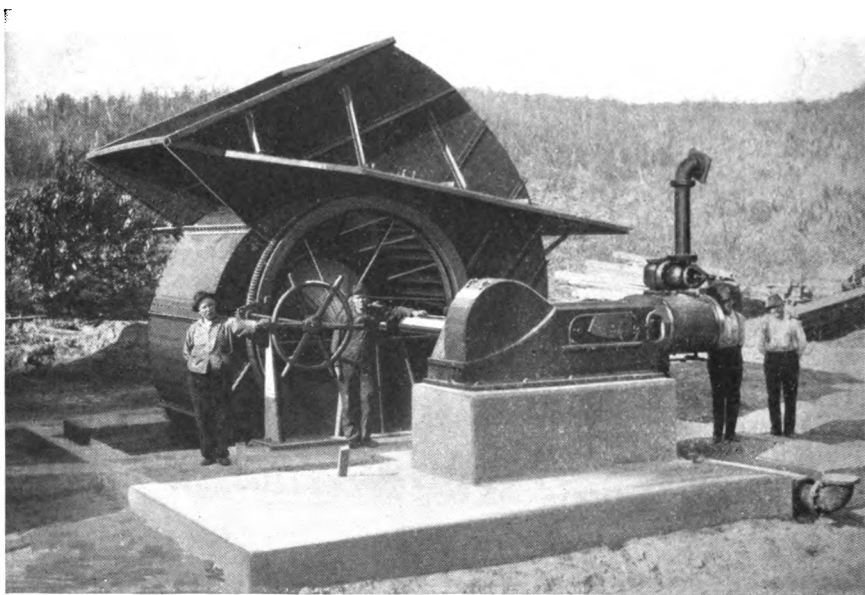
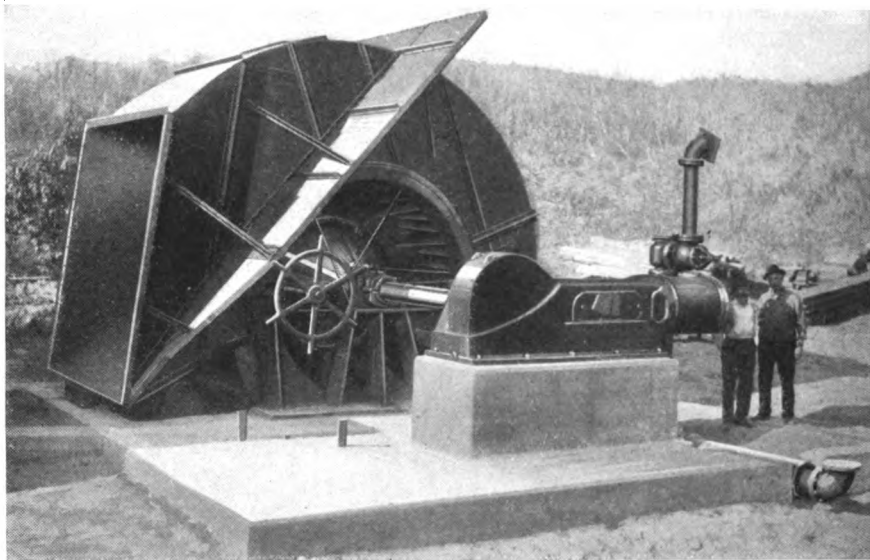


Diagram of bottom, No. 2 Mine, Lumaghi Coal Co.



Sullivan ten-foot fan and engine erected at Lumaghi No. 2 Mine and ready for the brick housing. The upper view shows the fan in position to blow air into the shaft, which is at the left. In the lower cut, the hood has been reversed, and the fan is in position to exhaust air from the mine

to center. They are 1,200 feet deep, leaving a pillar 80 feet thick between the two halves of the panel. A protection pillar, 60 feet thick, is left on each side of the main and panel entry systems. Rooms are turned on 65-foot centers from the stub entries, so that there are 18 rooms on each half of the double entry, or 36 in the panel. The rooms are carried 40 feet wide, leaving a 25-foot pillar, and are 200 feet deep. A 10-foot pillar is left between butting room faces, as each panel is kept independent, and no rooms or entries are broken together. The first room turned from each stub entry is placed so as to leave a 60-foot pillar between the rib and the panel entry, and on the stub entries turned first on the panel entry 60 feet of coal is left between the room face and the main entry for protection.

#### CONTINUOUS COAL CUTTER

Last January a chain mining machine of the Sullivan continuous cutting type was placed in the mine for a trial, and given an independent territory to cut, to determine its capacity. After squaring up the places assigned to it, this machine was more than able to cover the ground, and is now producing 250 tons per day in a running time of six to seven hours.

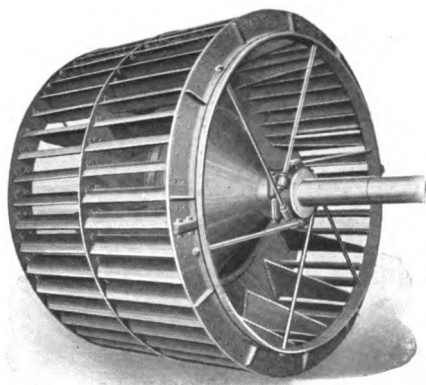
#### SHOOTING THE COAL

In blasting out the coal after this machine it was found at first that the face was not left square. The kerf or height of mining is six inches, the depth of the cut  $6\frac{1}{2}$  feet, and the height of coal  $7\frac{1}{2}$  to 8 feet, by 40 feet in width. The first practice was to shoot the room "double" with four holes. This method produced only as much coal per keg of powder as could be secured after the pick machine, mining to  $5\frac{1}{2}$  feet. A new system of shooting was then tried, employing three holes, one in the center and one on each rib; the holes are three feet from the bottom and drilled level to the back of the

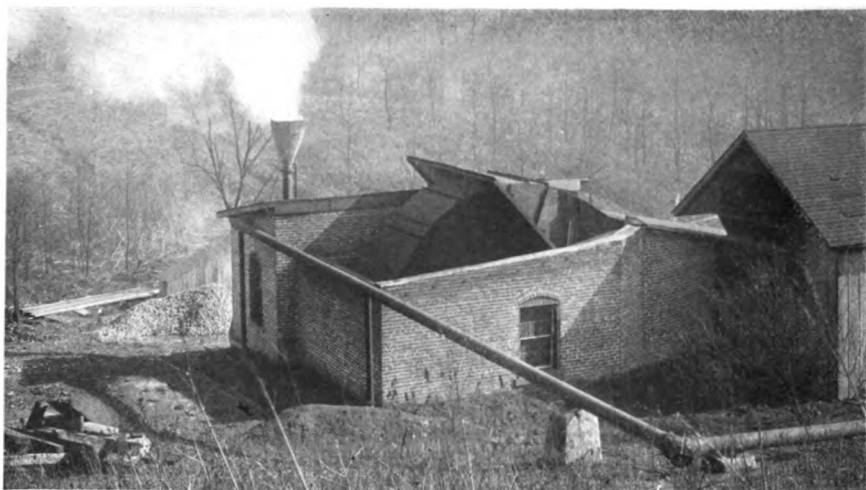
mining. This brings the coal down in such shape that all impurities are taken from it in loading, making the coal clean. Three holes are then drilled in the top coal; this takes a very small amount of powder, and the coal thus shot is easy to load, as almost all of it passes over a six-inch screen. This system of shooting leaves the rib and face perfectly square, and it is also found that one-half the amount of roof timbers are needed, as compared with those formerly necessary when shooting four holes and using a considerably larger amount of powder.

#### VENTILATION

The first fan installed in this mine was a Champion ventilator with reversible wooden hood. This fan had a capacity of 60,000 cubic feet of air per minute against a two-inch water gauge, and provided good ventilation until the mine reached a capacity of about 1,800 tons per day. When the present tonnage of about 2,500 tons per day was reached, it was found that a larger fan was needed. Owing to the size of the air shaft it was necessary to provide a fan of large capacity to work against high pressure. A Sullivan ten-foot, all steel, reversible fan was therefore installed, with a capacity of 250,000



Wheel of Sullivan Fan



The completed fan house, showing the simplicity of the structure necessary for this type of fan

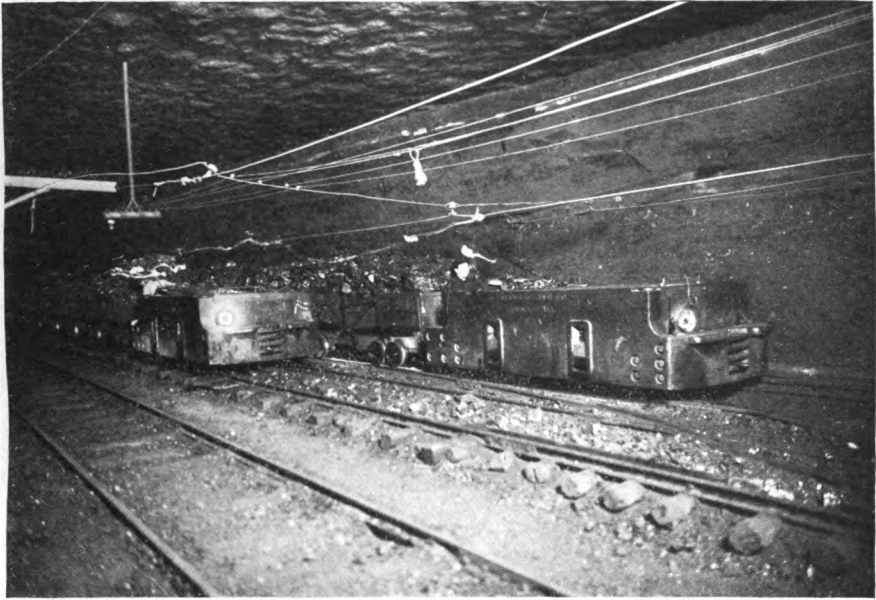


Lumaghi Coal Co., top works, No. 3 Mine

cubic feet of air against a six-inch water gauge. The fan is housed in a brick building, with a tunnel of brick and concrete to the shaft, making it entirely fire-proof. As yet, it has been necessary to run at only half speed, and the fan is producing 125,000 cubic feet against a

water gauge of 2.1 inches. There are four splits in the air, about 30,000 cubic feet per split. All overcasts are built of concrete and steel.

The sketch on page 519 shows the arrangement of the shaft bottom. The mine is divided, half of the workings on



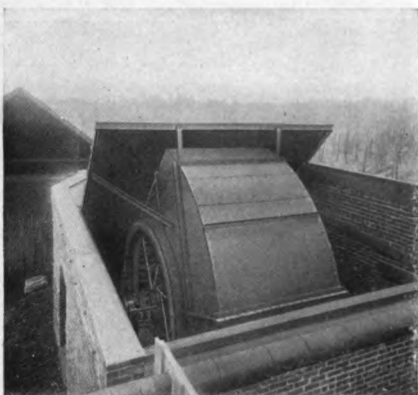
Lumaghi No. 2 Mine, the bottom

the west side and half on the east side. There are three tracks to the bottom of the shaft; one a passing track, and two for loads and empties, with a diamond on the loaded car side and a diamond on the empty car side. All coal is caged on the east side of the shaft. Two thirteen-ton electric locomotives haul the coal and distribute the empty cars. The motor from the east side pulls in on the straight track, and thence into the empty car track, getting the empties and returning to the east workings. The motor from the west side comes in to the bottom over the passing track, crosses the east load track and leaves its cars on an elevated load track on the south side. The elevated track is so arranged that the cars will drop by gravity into the bottom. This track to the bottom has a capacity of 70 loaded cars. The motor then returns to the passing track, and the west end of the bottom, taking its cars from either of the "empty" tracks.

The empty cars can be taken from either end of the tracks, so that motors will not conflict with one another. A waiting room is provided for the miners, so that when it is time for them to go on top they come in turns and go up ten men on a cage. This waiting room is arranged so that the east and west men come to it in turn and pass out the same way; seats are provided for 300 men. The room is lighted with electric lights and is well ventilated. A car repair shop and a concrete and steel stable for the mules are also on the bottom. The stable is between the intake and exhaust of the air, to secure proper ventilation.

#### CARS

The cars used have a capacity of  $2\frac{1}{2}$  tons each and are made of wood. The equipment is being changed as rapidly as possible to consist of steel  $3\frac{1}{2}$ -ton cars with brass bearings, which are more easily handled. This change, when completed, will mean an increase in production



The fan from above, showing housing

from 2,500 to 3,000 tons per day, as the territory is now developed for that tonnage and all the other equipment is of ample capacity.

#### TOP WORKS

The cars are hoisted in self-dumping cages by a 20 x 36-inch slide valve hoist, with a six-foot drum. The tippie, shown on page 515, has four tracks. The coal is dumped onto shaker screens, with a compressed air apron for handling the lump coal. By this means the coal is very thoroughly screened and sized to suit market conditions. All the fine coal is sent to the washer, and sized from No. 1 to No. 5, inclusive.

The power plant contains the hoist mentioned, the two air compressors, and a 150-K.W. direct connected generator, driven by a battery of eight 72-inch by 18-foot return fire tubular boilers. A new power plant, now in course of construction, will contain alternating current generators to provide 2,000 K.W. at 2,200 volts. This plant will be used to light the city of Collinsville as well as for power at the washer and mine. The 150-K.W.



Miners' waiting room

generator is being replaced by a 500-K.W. motor generator set, for supplying direct current to the locomotives and continuous electric coal cutters, of which more are to be installed. A well equipped machine shop takes care of all repairs.

#### NO. 3 MINE

The No. 3 mine of this company, operating in the same seam at Collinsville, is equipped with a steel tippie, self-dumping cages and shaker screens. The coal from this opening is sold chiefly to large steam plants on contract. It is mined by 13 Sullivan 825-pound pick machines driven by a Sullivan "WB-2" straight-line, two-stage air compressor with a 22 x 24-inch steam cylinder and 24 and 14½ x 24-inch air cylinders. A motor generator set is now being installed. The present output is about 950 tons per day.

Data and photographs for this article were obtained through the courtesy and assistance of Messrs. Louis F. Lumaghi, President; Joseph D. Lumaghi, Secretary and Treasurer; W. T. Scully, Superintendent, and Mr. Wandless, Master Mechanic.



Sullivan "DB-15" Hammer Drill, drifting in the Ray Consolidated Mining Co.'s mines, Ray, Arizona

### HAMMER DRILLING AT THE RAY

By R. S. WEINER<sup>1</sup>

When hand feed hammer drills were introduced in mining work a few years ago, it was thought that their use would be rather closely confined to block-holing, trimming, taking up floor, cutting hitches for timbers, and similar light drilling.

As these tools have been developed, however, mine managers have experimented with them and found that they may be used with speed and economy surpassing those of piston drills on mountings, under conditions of not excessive severity, in heavier ground breaking.

A concern which has found profitable use for these tools is the Ray Consolidated Copper Company of Ray, Arizona, which now owns about 25 Sullivan "DB-15" hand feed hammer drills. The company

<sup>1</sup> El Paso, Texas.

has made a systematic study of the use of various types of drills for different work, and employs air feed stopers and piston drills on mountings for other classes of excavation. The "DB-15" tools have been tested in sinking and in drifting work with satisfactory results, and a considerable amount of drilling of these classes is now performed with these tools.

Some time ago, two "DB-15" tools were given a tunnel heading. In the opposite heading two 2½-inch piston drills were driving through almost identical ground. The hammer drills averaged 11 feet of advance per 24 hours, while the piston drills averaged but eight feet. The method of work is as follows:

After a shot, the driller puts in his upper holes from the top of the muck



Looking west from Illinois shore across the Mississippi river at the foot of the D

pile, while the mucker is at work loading out the heap. The lifters are therefore put in last, when the muck has been all removed. This rock is chiefly porphyry schist, with some limestone, and would be classified as "fairly soft."

From April 5 to May 1, 25 days, a crew of one drillman and one mucker, using a Sullivan "DB-15" tool, advanced a 4 x 6 foot tunnel 254.5 feet. The cost of labor and supplies on the machine amounted to \$1.54, or \$.006 per foot of tunnel. The "DB-15" tool weighs 25 pounds, uses  $\frac{7}{8}$ -inch hollow steel, and consumes about 20 cubic feet of free air per minute at 90 pounds pressure. The photograph reproduced herewith shows how the drill is used in this work.

Another method employed in this mine for drifting is to drill the upper holes with an air feed stoper, and the down holes with the hand feed tool. The great advantage in using hammer drills in work of this class, as in stoping, consists in the fact that no time is lost in mucking or

the "set up," as in the case of piston drills, or in mounting the drill afterwards on the bar or column. Holes can be placed at just the point and angle required to break the rock properly, with the least amount of drilling and the smallest quantity of explosive.

The Ray is one of the largest porphyry copper mines in the world. Power for the mines at Ray is supplied over a high tension transmission line from Hayden, 18 miles to the southeast, where the reduction plant is situated. For some time past the monthly development work has averaged 10,000 feet. The ground was thoroughly prospected by drilling before development, so that dead work underground has been unnecessary. About 3,000 tons of ore are being hoisted daily, and the production will be increased as rapidly as possible until an output of 8,000 tons per day is reached.

The writer wishes to thank Messrs. Cates, Boyd and Wrenn for the information supplied him.



Des Moines rapids, across the site for the power house. Government canal in foreground

## DAMMING THE MISSISSIPPI

By R. E. ELLIS<sup>1</sup>

Power development of the Mississippi River at the Des Moines Rapids, between Keokuk, Iowa, and Hamilton, Illinois, was projected as early as 1848, but it was not until 1900 that definite steps were taken which are now making this enterprise a reality.

The Mississippi River Power Company secured the necessary authority from the United States government in 1905 and is now building a dam which will develop 200,000 electrical horsepower. A dry dock and lock of ample proportions are also being constructed. The latter will replace the present government canal, eleven miles long, and the tier of three locks, built in 1877, which now are necessary to enable vessels to pass the rapids at all times except the highest water stages. The dam will create a lake 65 miles in length, and averaging a mile and one-

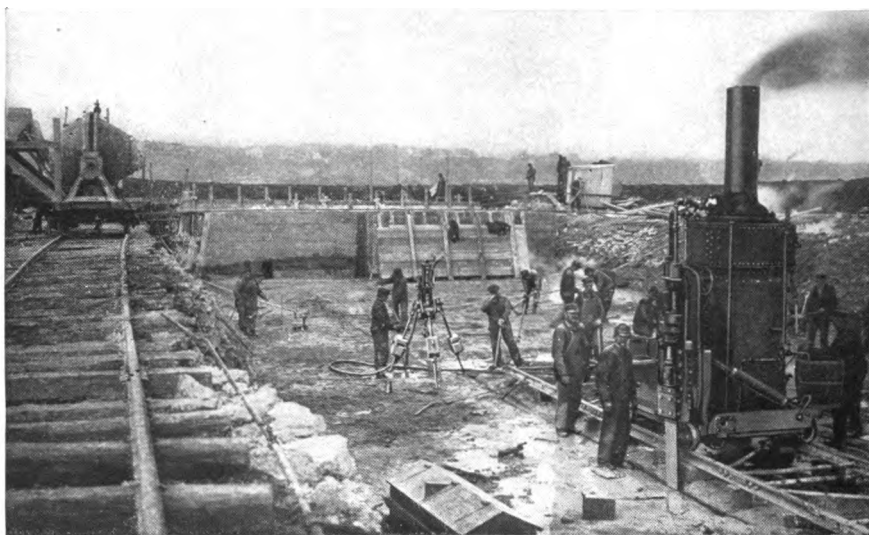
<sup>1</sup> Chicago, Illinois.

third in width. This lake will submerge the Des Moines Rapids and provide at all seasons of the year a deep water stage up the river to a point 20 miles above Burlington, permitting vessels of much greater draft and carrying capacity to use the river than has been possible heretofore.

This plant is situated within reaching distance of a large number of cities and towns in Iowa, Illinois, and Missouri, which are large users of power for manufacturing purposes; such are Moline, Davenport, Rock Island, Burlington, Quincy, and Alton, not to mention Keokuk and Hamilton. The initial installation of 120,000 horsepower is expected to be in operation by July 1, 1913. Arrangements have already been made for marketing 60,000 electrical horsepower of this initial output with public service companies in the city of St. Louis, Missouri, the remaining 60,000 horsepower will undoubtedly be



**Beginning work on the dam; overburden cleared away on both sides of trench. channeler and drills excavating**



**Sullivan class "Z" Channeler and Rock Drills excavating trench for toe of dam**

contracted for in a few of the larger cities in the surrounding territory long before the date set for the completion of the dam.

#### GENERAL FEATURES

This dam is said to be the second largest in the world, being exceeded in size only by the Assuan dam on the Nile, in Egypt. Some idea of the magnitude of the enterprise may be formed when it is stated that the dam, including its abutments, will be seven-eighths of a mile, or 4,560 feet long, while the spillway section will be 4,278 feet in length. The structure will be 32 feet in height above the river bed, and 42 feet wide. The operating head will vary from 39 to 21 feet.

On the top of the spillway will be an arched bridge from which 119 steel gates, each 30 feet wide by 11 feet in height, will be operated by electric hoists, and by which the water level in the lake above the dam will be kept nearly constant at all seasons. The dam will be of solid concrete, without reinforcement, and will be made secure in the river bed by a trench, excavated in the rock. The river bottom and walls at this point are of hard, solid blue limestone, without faults, mud pockets, or fissures, so that leakage or settling will be out of the question. The upstream face of the dam will be vertical; the downstream face an ogee curve; i. e., the upper part will be a parabola over which the water will spill, the lower, an arc of a circle to throw the water away horizontally from the toe of the dam.

The power house will be located on the Iowa side of the river. It will be 1,400 feet long and 125 feet wide. The substructure will be built entirely of concrete, and in it will be molded the water passages and water wheel chambers. The superstructure will be of brick and steel, and the total height from foundation to roof will be 130 feet. The generators will comprise 30 units, each with an independent governor and auxiliary equipment. The power house will be protected from

ice and logs by a concrete fender, 2,800 feet long, built upstream from the upper end of the house, and curving in to the shore. Large arches below the water level will permit free passage for the water.

The lock will be adjacent to the power house, and will afford passage for boats of eight-foot draft. The construction of the power house, lock, dry dock and dam will require over half a million cubic yards of masonry, 650,000 barrels of cement, and 7,000 tons of steel.

It will be impossible, in the limits of this article, to give as complete details regarding the construction work and methods, as would be, no doubt, interesting to many readers. More detailed accounts of the various features will be found in the illustrated bulletins issued from time to time by the power company, from their office at Keokuk.

#### CONSTRUCTION PLANTS

The hydraulic construction work is being done by Mr. Hugh L. Cooper, vice-president and chief engineer of the Mississippi River Power Co. Mr. Cooper has carried to a successful conclusion some of the largest hydroelectric power developments in this country, including that of the McCall Ferry Power Company, on the Susquehanna River, near Harrisburg, Pennsylvania; and the largest of the Niagara Falls enterprises. The electrical construction is in charge of the Stone and Webster Engineering Corporation.

The construction is carried on by two separate plants, one on each bank of the river. Each organization is complete and independent of the other. The dam itself is being carried out from the Illinois shore to meet the power house and lock which are under way on the Iowa side.

#### THE DAM PROPER

The general method on which the dam is being constructed consists in laying bare a section of the river bed 400 feet long, by means of a cofferdam. As the



Dam traveler and Illinois construction plant

dam is completed, the cofferdam is extended 400 feet at a time, across the river. The work involves first, removing the overburden from the path of the dam by means of a steam shovel, second, cutting a trench in the limestone rock of the river bed, and third, erecting the concrete dam structure itself.

#### DRILLING AND CHANNELING

The rock is excavated by means of Sullivan rock drills, size "UC" ( $2\frac{3}{4}$  inches) mounted on tripods. The toe of the dam is locked into bed rock by a trench three feet deep and twelve feet wide. The walls of this trench are cut with Sullivan class "Z" stone channeling machines, before the rock between is blasted. This prevents shattering the rock adjacent to the walls, and eliminates filling or trimming. The channelers have cut as high as 80 square feet per day of ten hours; the limestone being hard and interspersed with seams of chert. "Z" shaped solid bits are used.

#### CONCRETE CONSTRUCTION

The construction plant on the east bank is a model of convenience, economy, and speed in handling materials. The entire plant is within a radius of 600 feet from the end of the dam, and is shown

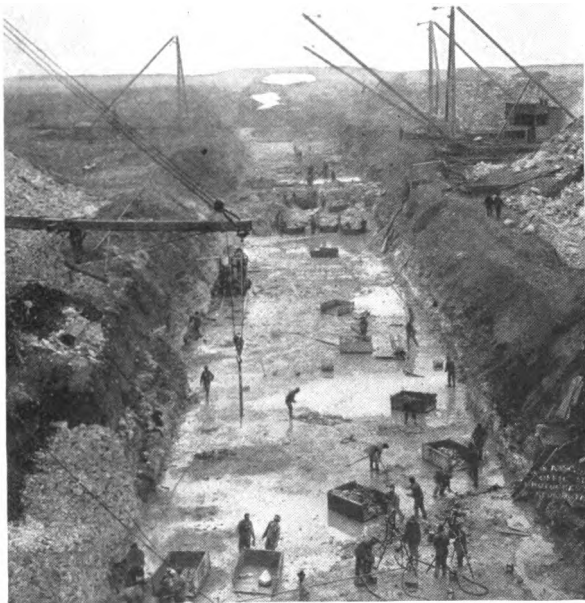
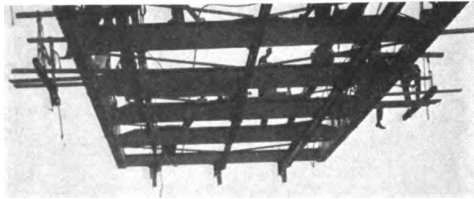
in the photograph on this page. The stone for the concrete plant is quarried by well drills and a 100-ton steam shovel at a point only 300 feet from the crushers. The quarry has a face 35 feet high, and the output is about 1,000 cubic yards per day. The stone is dumped from the 12-yard dump cars, by air power, directly from the track level into a No. 10 crusher. It is then screened, and served either to a No. 7½ crusher, or directly into a storage bin. The No. 7½ crusher delivers to a conveyor belt which carries the stone up an incline to the storage bin. The crushed stone bins are close beside the sand bins and both are over the terminus of an inclined railway which carries the stone on two tracks to the mixer bins, which have a capacity of 700 cubic yards. The mixer plant consists of four units with a capacity of about 30 yards per hour each, which gives a possible capacity of 1,200 yards of concrete per ten hour day for the entire plant. The mixers discharge into one and one-half yard buckets on flat cars; trains of these flat cars with the loaded buckets are run out onto the dam, where the buckets are handled by a large traveling crane which operates three trolley systems by means of three separate hoists and traveling engines. This crane, called the dam traveler, weighs 175 tons.

It runs on tracks built permanently on the dam and travels forward as the construction work progresses. It can handle material 150 feet ahead of the farthest point of the completed work. The spillway section is a series of 119 arches, 36 feet wide from center to center of intervening piers. The forms for these piers and arches are of structural steel. They are constructed on small piers placed in the bed of the river, on which are placed cast iron base plates; the alignment of these base plates is the only instrument work necessary to line up the forms, as the legs of the forms are provided with sockets which are doweled into place in their corresponding base plates.

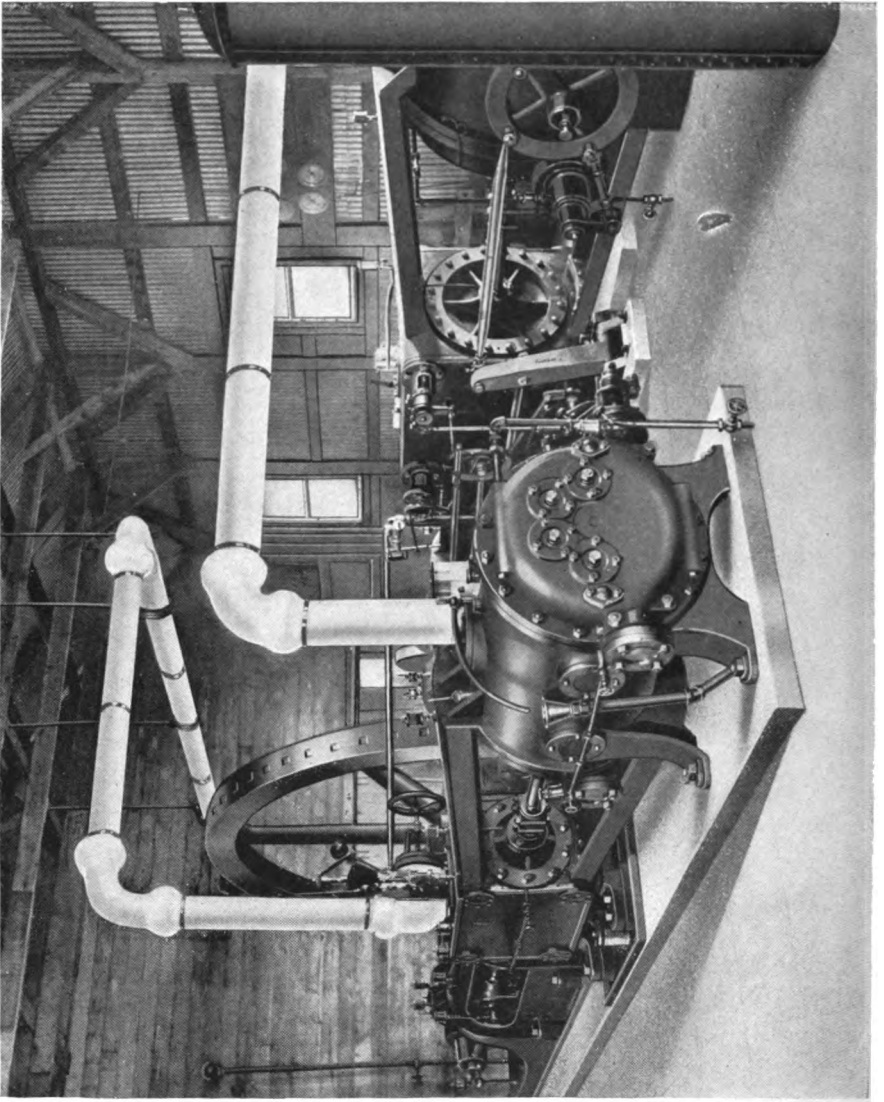
#### POWER HOUSE

The area covered by the power house, lock, and dry dock is about 37 acres. On April 30th, 15½ acres of the river bed were laid bare by a timber crib cofferdam 700 feet wide and 936 feet in length. The remainder of the area was unwatered about July 1st. The construction of the cofferdams was so tight that since the water was first pumped out, leakage has been almost negligible. The rock to be removed, about 300,000 cubic yards, is about equal to that which will be needed for concrete in the lock and power house, so that it is likely that a quarry on this (west) side of the river will not be necessary. A crushing plant has been installed in the bed of the river to handle

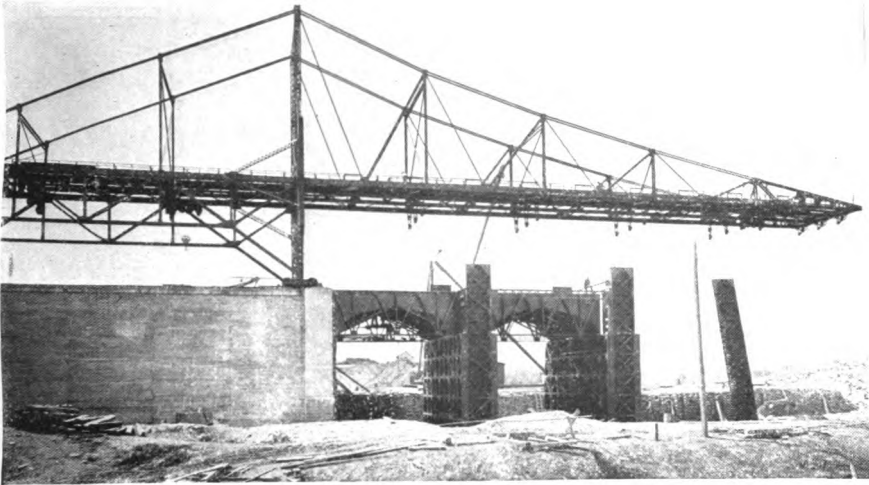
this stone. The view on page 526 shows the river at the site of the power house, with the government canal in the foreground. The storage yards for lumber and other materials, as well as the air power plant, are on the shore side of the canal, and a drawbridge, built for the purpose, provides transportation. The Chicago, Burlington, and Quincy Railroad runs close to the canal. Its tracks will have to be elevated 30 feet on account of the raising of the water level. Page 534 shows the first section of the power house site and



Under the dam traveler; channeler and drills at work in trench



Sullivan Corlies Cross Compound Two-stage Air Compressor, capacity 2500 cubic feet, at the Illinois plant



Construction on the dam; dam traveler at work placing steel forms

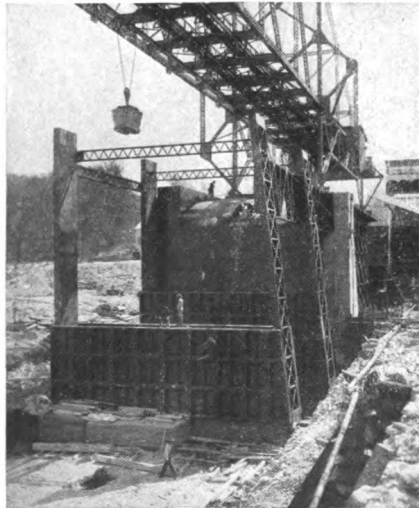
the cofferdam just after unwatering was completed.

#### AIR THE MOTIVE POWER

Compressed air was selected as the most economical, convenient, and reliable medium for operating the various engines and machinery on the work, on both sides of the river. There is a central air plant at each of the two camps, each consisting of a Sullivan Corliss cross compound two-stage compressor, with steam cylinders 16 and 32 inches and air cylinders 30 and 18 inches in diameter, having a common stroke of 42 inches, and a rating of 2,600 cubic feet of free air per minute, at 75 R. P. M. The compressor at the Illinois plant is shown on page 532.

These compressors are of heavy duty construction, to withstand the severe and continuous service required of them. The west plant is fitted with a jet condenser, but that on the Illinois shore is run non-condensing on account of its distance from a proper water supply. A steam receiver and reheater below the engine room

floor reduces heat losses in transmission from one steam cylinder to the other. Air efficiency is assured by large water jackets on the air cylinders and by a large receiver intercooler. The air inlet valves



Steel forms for concrete work; view beneath traveler

are of the semirotary pattern, positively driven by eccentrics on the engine shaft. These valves, as well as the automatic poppet discharge valves, are so placed and designed as to keep down clearance and leakage to an unusually low point.

Each unit discharges into a large receiver outside the engine room. Air at 100 pounds pressure is supplied from this receiver through an eight-inch main, to the various departments of the work. There are about 3,000 feet of air lines on the west side of the river, while the mains and service pipes on the Illinois shore aggregate 2,000 feet at present.

Compressed air from these plants operates the rock drills used in excavation; the engines which drive the concrete mixers; the hoisting engines on the crane or dam traveler (in this instance, a tank or receiver on the traveler provides against fluctuations in pressure). Air is also used for pumping, hoisting, painting, cleaning belts, testing rock, and in fact, every operation requiring power, except the haulage of stone, which is done by steam locomotives.

#### ORGANIZATION AND SYSTEM

To even the untechnical visitor, the effects of organization and systematic

working methods are plainly evident. There is no unnecessary handling of material. The various elements of the plants are so related to each other that labor, time, and power are conserved to the fullest extent. Storage yards are conveniently placed, and supplies and equipment are purchased and maintained well in advance of actual requirements, so that no delays occur to construction, but each step is taken at the exact time planned, and the entire work progresses with the greatest possible despatch and economy.

#### PROGRESS

On August 1, the dam and spillway section had been advanced across the low ground or shore 1,500 feet. The rate of construction is about 450 feet per month for the completed concrete work. During July the advance was 420 feet. Excavation for the power house, wheel pit, lock and dry dock is progressing rapidly. The entire area is now unwatered, and construction of the foundation for the power house has been begun.

The writer's thanks are due the officers of the Mississippi River Power Company for data and photographs used in this article.



The first section of the power house site, unwatered by the cofferdam

## A DIFFICULT FEATURE OF DIAMOND DRILLING

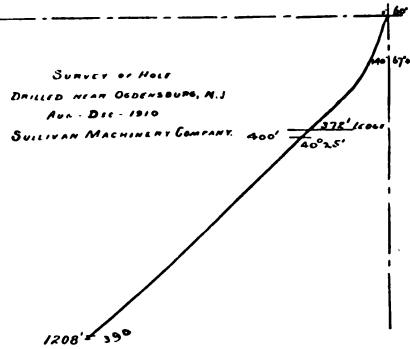
By W. T. ROBERTS<sup>1</sup>

When diamond drilling explorations are undertaken from the surface, stand pipe must be sunk to bed rock or ledge through the overlying deposits, which may consist of soil, sand, clay, gravel, boulders, etc. This overburden varies in depth from a few feet to several hundred feet. Many deep stand pipes have been sunk vertically, and stand pipes at an angle, through light overburden, are common and present no extraordinary difficulty. Deep stand piping at an angle is, however, an unusual undertaking and requires much skill and experience as well as time for successful accomplishment.

In depth and inclination, a stand pipe which has been successfully driven near Ogdensburg, N. Y., while prospecting for zinc ore, presents unique features of interest. The pipe was started at an angle of 60 degrees from the horizontal and sunk through a deposit of sand and gravel, quicksand, boulders, and a mixture of mica and sand. The ledge was finally reached at a depth of 372 feet, at which point a test of the angle of the pipe showed 44 degrees. The accompanying sketch shows the line of the pipe, as given by tests made at various depths with a hydrofluoric acid glass clinometer.

The hole was started on August 4, 1910, and the line of casing reached the ledge on December 10, 1910, making a total of 111 working days consumed, or an average of 3.35 feet per working day of ten hours.

Boulders three or four feet or more in thickness were frequently met with, making the use of the diamond bit necessary in order to place a shot to break them. Between the depths of 146 feet and 265 feet 50 blasts of dynamite were required to advance the pipe, employing two to three pounds of dynamite for each blast.

<sup>1</sup> Chicago, Ill.

The shots were fired with an electric blasting battery.

At one point where the formation consisted of clay, cementing was tried in an attempt to hold open the hole until the ledge was reached, but it was found when drilling out the cement that the diamond bit did not follow the cement core, but instead deflected into the softer clay, thus making it necessary to advance the pipe through this material.

After the ledge was reached, the casing was drilled into the limestone and cemented in place. The work was continued with the diamond bit until the hole was finished at a depth of 1,208 feet, measured along the hole. It will be noticed from the diagram of the hole that from 400 feet to the end of the hole the angle remained practically constant, there being a decrease in the angle of but  $1\frac{1}{2}$  degrees in 808 feet.

The above described work was performed by the Sullivan Machinery Company, using a regular "B" Diamond Core Drill and equipment.

The deep stand piping in this hole was not anticipated, inasmuch as two previous holes drilled near by required only 25 feet and 51 feet of stand piping respectively. Hole No. 1 was drilled at an angle of 38



A Diamond Drill rig

degrees and hole No. 2 at an angle of 60 degrees from the horizontal. If such deep overburden could have been foreseen, other sizes of piping would have been used than those which were available, as described above.

It will be interesting to note that after the ledge was reached, and drilling started with the diamond bit in solid rock, the rate of progress was greatly increased. It required 37 days to complete the remaining 836 feet. The crew during this time worked two shifts per day, of ten hours each. The progress in this latter drilling was 22.6 feet per day, or 11.3 feet per shift. During this time the hole was cemented twice. The drilling from 372 feet to the finish of the hole was mostly in limestone, although occasional wide bands of quartz, hornblende, granite, dyke, and pygamite were encountered.

## GOVERNMENT DRILLING IN NOVA SCOTIA

FROM THE "CANADIAN MINING JOURNAL"

"The government of Nova Scotia adopts the liberal policy of keeping and operating seven core drills for the benefit of the mining community. During the year 1910, five drills, of which three were diamond drills, and two calyx drills, were kept in commission. The total footage drilled was 5,222 feet. Of this footage, 4,500 feet were done by diamond drill. In all, fifteen holes were sunk, and in every case coal was the mineral sought. The strata drilled included sandstones, shales, conglomerates, clays and grits of many varying degrees of hardness, and of every kind of texture.

"The average cost per foot of diamond drilling is reported as 93 cents; while the corresponding figure for the calyx is \$1.44. The deepest hole bored was sunk with a two-inch diamond drill. The depth attained in this instance was 1,217 feet; the cost per foot, 72 cents; the highest rate of boring per hour, 5 feet 3 inches; and the average footage per hour 1.2 feet. It is interesting to compare these figures with the performance of a 6-inch calyx. The calyx hole was sunk to 560 feet. The highest rate of boring per hour was 6 feet 4 inches; the average footage per hour 1.27 feet; and the cost per foot \$1.44.

"It is not intended to institute comparisons between the two types of drills. The figures above are quoted merely because of their intrinsic interest. Incidentally it is noteworthy that the coal operators are the only persons securing the drills. It is surely worth while for a few of the gold mine operators to put in a claim. Under proper control the diamond drill, which probably would do better work in the gold measures, could be utilized to great advantage."



Sullivan "DB-19" hammer drills on a shallow bench, Shenango Limestone Co.

### QUARRYING WITH HAMMER DRILLS

By WILLIAM MCKEARIN AND R. S. HUTCHISON

Machine drills have replaced hand drilling in crushed stone quarries to a very large extent, but there are still many concerns which cling to the old method, or which do not use air or steam drills for all of the purposes to which they might be applied profitably. The development of the hand feed air hammer drill now enables hand drilling to be dispensed with entirely, at a great saving of time, labor and cost of production.

A quarry which has recently given up hand drilling with agreeably satisfactory results is that of the Shenango Limestone Company at Newcastle, Lawrence County, Pennsylvania, which produces some 300,000 tons of crushed stone per year for ballast and furnace flux.

Until about a year ago all drilling, both on the benches and in pop-holing, was done by hand on a contract basis. That is, the quarry was split up into sections, each assigned to a separate laborer or contractor. The contractor bought his tools and dynamite from the company, and received a fixed price for the stone

when he had loaded it on the cars ready for the crusher. The stone was hauled at company expense.

This system involved a number of disadvantages. The company found difficulty in securing a regular supply of stone for the crusher, because each man worked as slowly or as fast as he desired, and only when he desired. A very long working face was necessary, to provide a section for each of the large number of men needed on this system. The use of explosives was entrusted to many individuals, thus rendering the liability of accidents a high one.

Trouble also arose when the quarry manager wished to discharge men, in agreeing on the amount and value of the stone already drilled or ready to load.

About a year ago the company experimented with machine drills and, after testing various makes and sizes, purchased a Sullivan "UE-11" 3¼-inch tappet valve tripod drill and Sullivan "DB-19" hand hammer drills, of which it now has eight in use. Drillers are now paid by the



**Sullivan rock drill on bench, Shenango Limestone Co.**



**Block-holing**



**Sullivan Hammer drill, Shenango Limestone Co.**



**Waller Bros. Stone Co. McDermott, Ohio**



**Splitting stone for paving blocks in an Ohio quarry**

day, and all loading and firing of holes is done by skilled shooters, also paid by the day. The loading is paid for by the ton. This arrangement places the superintendent in full authority and he is not handicapped, as under the old system.

The tripod machine has drilled as high as 96 feet of 12-foot holes in a ten-hour day, while with the hammer drills, 93 feet is an excellent day's work, and 65 feet a fair average. A good contract

quarryman, drilling by hand, would average eight feet of deep hole per day and ten feet of pop-holes. The output of this plant has been largely increased, and the cost per ton of stone reduced some eight or ten per cent.

#### USES OF HAMMER DRILLS

The Sullivan hammer drills weigh 40 pounds, and have a capacity of five feet in depth. Hollow, one-inch hexagonal

steels are used, sharpened with a six-point "rose" bit. These tools are the ones generally selected for crushing quarry purposes. Holes must often be drilled in places not easy to reach, and for which a heavier tool would be too cumbersome, while smaller sizes have been found wanting in capacity and wearing qualities. Page 537 shows a group of these machines drilling a bench three feet high in the Shenango quarry. These shallow benches, two to five feet in height, must frequently be lifted, on account of variation in stone, of the stratification, or for the purpose of extending track, to secure better loading facilities.

The drills at Newcastle put in holes averaging 18 inches deep, but frequently running up to four or five feet, with speed and economy. Much pop-hole work is done also, in breaking up large fragments, or in freeing pieces which are cracked but still attached to the face. These holes vary from five to eighteen inches in depth. Another application is that of taking up "hog-backs" that interfere with track-laying.

#### OTHER APPLICATIONS

The Holran Stone Company, at Maple Grove, Ohio, employs three Sullivan "DB-19" drills in the quarry, and a Sullivan "DB-15" tool, weighing 25 pounds, for lighter work at the crusher. The stone is loaded at the quarry by a steam shovel, and frequently pieces too large for the crusher are inadvertently placed on the cars. These are removed from the car by a small air hoist, and broken by pop-holes and plug and feather wedges. One man, with one of these tools, can do the work of four or five with sledges.

#### CLEANING OUT HOLES

A valuable feature of the Sullivan hammer drills is brought out at this quarry. The stone is damp, and, particularly at the bottom of the pit, is loose and soggy. With other types of hammer

drills, trouble is experienced in keeping the holes free of mud and cuttings in such rock. The Sullivan drill, however, is fitted with a patented exhaust valve, and an arrangement of ports which permits the runner to force a large or a small part of the exhaust air down the drill steel at will. By pouring a little water down the hole, the mud is kept thin, and readily blown out of the hole.

#### DEEP HOLES IN A TEXAS QUARRY

The deepest drilling done with hand feed hammer drills, so far as information is available, is reported by Risley Bros. & Company, of Jacksboro, Texas. This company's rock is hard limestone, in layers from four to twelve inches thick. A portion of the quarry is worked in eight-foot faces, and here the drilling is done entirely by Sullivan "DB-19" drills, using hollow steels, as shown in the cut on page 540. The rock here is interspersed with shallow mud seams or pockets. The use of the patent exhaust valve referred to above, enables mud and cuttings to be thrown with ease from the eight-foot holes. When the drill strikes a pocket of mud, the steel is caught by a wire hook and held a little above the mud, while with the other hand the drillman keeps the tool running with a light blow, all of the exhaust air being thrown down the steel.

One eight-foot hole which the writer timed was completed in 21 minutes. The following records of block hole work taken from the company's books, are a good indication of the capacity of these tools. They were made with one "DB-19" drill.

Date	No. of Holes	Foot- age	Hours	Av. Depth	ft. per hour
June 2, 1910	73	197	10	2.7	19.7
July 11, 1910	83	130	10	1.5	13.0
July 15, 1910	95	213	10	2.25	21.3
Wk. of Apr. 1, 1911	464	1441	110	3.1	13.0
Wk. of Apr. 8, 1911	428	845	80	1.97	10.6
Wk. of Apr. 15, 1911	461	1443	113	3.13	12.7
Wk. of Apr. 29, 1911	374	1123	103.5	3.0	10.8
Wk. of May 5, 1911	484	1296	110	2.7	11.8

**DRILLING SANDSTONE**

Sullivan "DB-19" drills are used at the sandstone quarries of Waller Bros.' Stone Company, McDermott, Ohio, to break the stone into proper sizes, after it has been freed on two sides by a channeling machine. The stone is in horizontal layers from 5 to 24 inches thick, separated by an inch or two of shale. Plug holes from three to eight inches deep are drilled with hollow one-inch bits, and the blocks split with plug and feather wedges. An average rate of progress is 75 feet of hole per hour. In the grindstone quarries, where the stones are cut out round, the hammer drill is used to put in holes two

to five feet deep under the stone proper, to receive a small charge of powder. This work formerly was done by hand, as the holes could not be properly placed with a tripod drill. This company's mill is equipped with machinery of the most modern character, including about eight gang saws, each of which is driven through gearing by an independent motor, thus doing away with all line shafts and belting.

It is hoped that these rather fragmentary notes may be of interest and assistance to quarrymen, in suggesting economies which may be effected under their own working conditions by the use of hammer drills.



Sullivan "DB-19" hand feed hammer drills drilling holes eight feet deep, with hollow steel in quarry of Risley Bros. & Co., Jacksboro, Texas

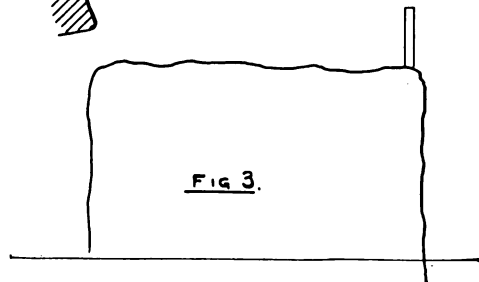
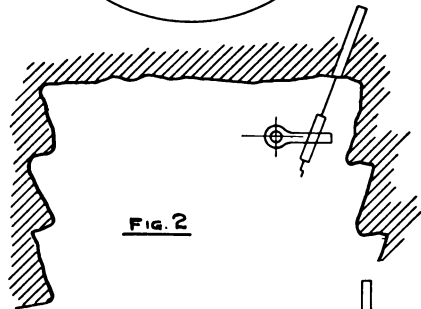
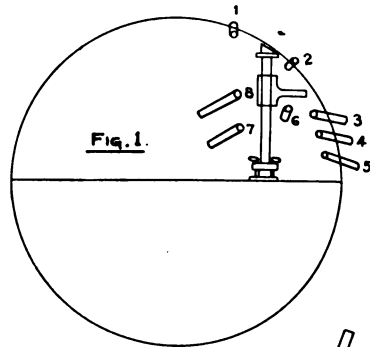
## LONG COLUMN ARMS IN TUNNELS

In driving tunnel headings of oval or semicircular cross section, ranging from 10 or 12 up to 18 or 20 feet in width on the floor, a customary method is to employ two columns, each carrying two drills. In order to complete the round and break the ground to the best advantage it is necessary either to move the columns or to set up a third column. A device for obviating this delay has been used recently with success in tunnels on the line of the New York City water supply aqueduct. It consists merely of a column arm of unusual length, 30 or 36 inches. This is set near the bottom of the column, and gives the drill a much wider range in placing the holes than the arm of ordinary length.

With this long arm a tunnel wall or rib may be carried straight, instead of as a series of offsets, with the resulting roughness, which must be reduced by filling or trimming. In the sketch, figure 1, is shown a column with a short arm. It must be set far enough from the rib to permit the arm to swing between the rib and the column when the arm is placed for drilling the holes at the top of the tunnel.

Hole No. 1 is drilled with the arm on the left side of the column. The arm is then swung to the position shown in the cut, and holes Nos. 2, 6, 7, and 8 drilled. If this arm or a bottom arm of the same length is used for the lower rib holes, Nos. 3, 4, and 5 would be drilled as shown in figure 2, leaving an offset.

The use of a long arm on this column allows holes Nos. 3, 4, and 5 to be drilled as shown in figure No. 3, and the difference



in appearance of the rib when the two arms are used is shown by figures Nos. 2 and 3. These arms are, of course, made of extra strong material to withstand the strain placed on them when the drill is working at the outer end.

# A LETTER TO YOU

SUBJECT: LOWER STOPING COSTS

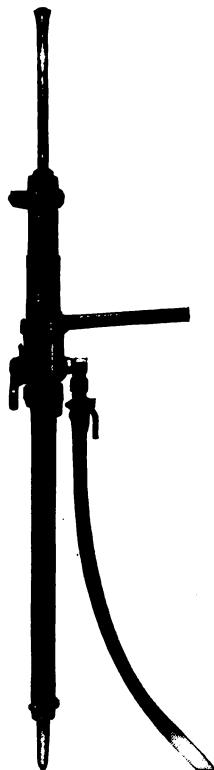
"We have tried Sullivan Stoppers in competition with the other leading makes of hammer drills. We have found that Sullivan Stoppers cost us less per foot of hole drilled, or per yard of rock taken out." "They are very rapid drillers, but take less air and fewer repairs than our other stoppers."

"We have learned that our bill for broken drill bits is smaller on Sullivan Stoppers, and that they are more popular with our men, because they rotate easier, run in better balance and have less jar and vibration than any of the other stoppers we have tried."

"We shall buy Sullivan Stoppers exclusively after this."

This letter was written in our own office. It is a composite letter—the opinion of mining companies in all parts of the United States, Canada, and Mexico, as reported direct to us and backed by repeated purchases of DA-21 Sullivan Stoppers,

Write any of our offices for the names of these concerns and details of their experiments; or better still, ask for one or more drills for a free trial in your own mine.



*Write for new Bulletin 166-C*

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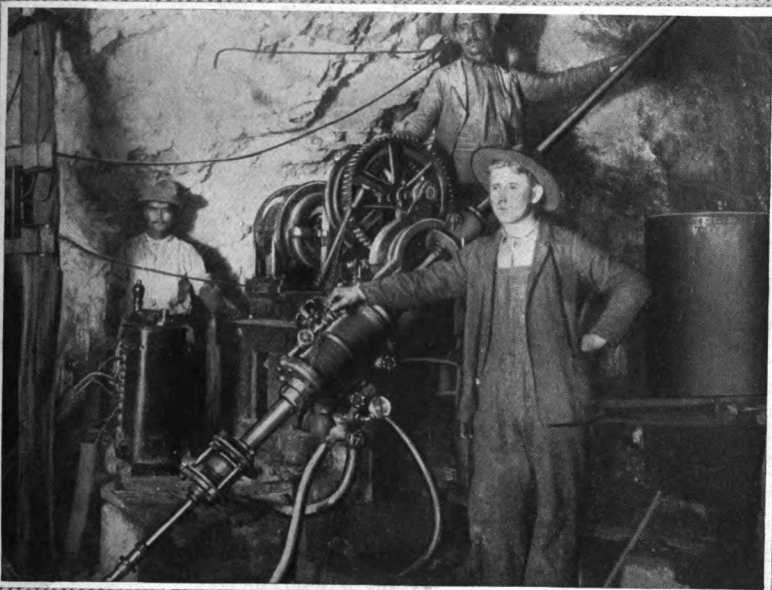
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# MINE AND QVARRY

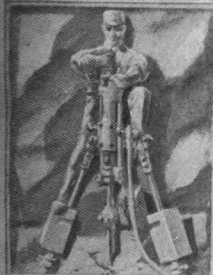
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NOVEMBER, 1911

WHOLE No. 20



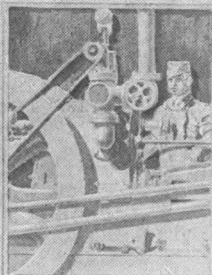
SULLIVAN DIAMOND DRILL BORING AN UPPER HOLE



HOISTING FROM SHALLOW MINES

MINING SLATE IN MAINE

MICHIGAN COAL PROBLEMS



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# MINE AND QUARRY

Vol. VI, No. 2

NOVEMBER, 1911

Whole No. 20

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## EDITORIAL

The failure of the masonry dam at Austin, Pa., on September thirtieth, closely followed by the washing out of dams near La Crosse, Wis., has centered the attention of engineers on the elements of weakness responsible for these and other similar catastrophes.

At Austin, a section of the dam, together with the rock stratum to which it was fastened, slid bodily down the stream. In January, 1910, just after the dam was finished, a short slide occurred which gave warning of what might be expected later. The warning was disregarded. The formation underlying the dam consisted of horizontal layers of sandstone, from 8 to 36 inches thick, with beds of shale and disintegrated sandstone between. Water, seeping through this loose material, softened it so that the dam and top layer of solid rock slid, when sufficient pressure was applied.

The discussion now in progress emphasizes the need of state supervision of the plans for, and construction of, dams, to insist that proper precaution be taken to prevent failure. It emphasizes with especial vigor the fact that the key to the strength or weakness of masonry dams lies in their foundations, and that the

greatest pains must be taken to obtain a complete knowledge of the ground below the dam site, before work is begun. In the Austin case, the builders knew in a general way, what the rock was like, but in spite of the fact that the formation is one regarded as dangerous by experienced engineers, no steps were taken, apparently, to investigate it to any depth, or to provide sure protection against the leakage, which began as soon as the dam was completed, and finally destroyed it.

Mr. Alfred D. Flinn, in a letter to *Engineering Record*, (October 21), says;

"Nowhere have I seen any mention of the examinations of the dam site to determine the character of the foundations before the structure was built. Such an examination with core drills is essential and should be made before the drawings for an important dam are completed. Especially is this true in a place where the rock is in approximately horizontal layers, interbedded with shale or clay. Such examinations with the drill take time and cost money, but they should be regarded as a necessary part of the construction, quite as much as the masonry itself. The foundations of masonry dams must be made secure beyond suspicion."

The practice of testing foundation sites with core drills is, happily, on the increase. A very large amount of this work has been done by the engineers of the New York Board of Water Supply, of whom Mr. Flinn is one. The bed of the Colorado River at Austin, Texas, where a dam slid eleven years ago, has been tested with diamond drills prior to reconstruction; so has the Missouri River, where the first Hauser Lake dam was washed out in 1908. The Goat Rock Dam of the Columbus Power Co., on the Chattahoochee, near Columbus, Georgia,

and the water power dams of the Portland Railway, Light and Power Co. on the Clackamas River, in Oregon, are shining examples of thorough diamond drill core testing before construction, instead of after failure.

Methods of work on these two undertakings were described in the July, 1910, and October, 1910, issues of this magazine. Reference is made elsewhere in this issue to work of this nature recently done at a Mexican water power site.

## MINING SLATE IN MAINE

By H. W. BAKER<sup>1</sup>

The slate industry of Monson, Maine, dates back about forty years, to the time of ox-carts and hand labor. At that time the sole product was roofing slates, which were carted to Bangor and shipped by water to New York or Boston.

The real importance of these deposits was not appreciated, however, until the rapid advance in the manufacture of electrical apparatus created an enormous demand for an easily worked stone with high insulating properties. For this purpose the Monson slate ranks very high: electrically, it is a perfect insulator, and mechanically, it is strong, takes a high polish, is obtainable in any sizes up to the limit of electrical requirements, while in color it is an unfading black. The average value of Monson slate manufactured mill stock in 1910 was 39 cents per square foot, as compared with that of Vermont at 26 cents and Pennsylvania at 16 cents.

Located in a low range of hills about 14 miles from Moosehead Lake, Monson cannot claim the advantage of proximity to market, nor are the northern winters a favorable factor in stone quarrying. Notwithstanding these and other drawbacks, the history of the slate industry in Monson has been one of constant advance; the demand always keeping well ahead of the production. The quality of this slate has received an increasingly wide-spread recognition and progressive management has discounted the increasing difficulties of quarrying by the aid of modern machinery.

<sup>1</sup> Rockland, Maine

### CHARACTER OF THE DEPOSIT

The geological formation at Monson consists of a series of parallel veins standing vertically and with a strike running approximately E-W. Along the strike, this series of slaty rocks extends to Brownville, some 25 miles, while the extent across the strike is 20 or more miles. Of the hundreds of veins comprised in this large area, the vast majority consist of hard, indurated, bastard slate, criss-crossed by igneous intrusions and quartz, and are of little commercial value. The remaining veins, which are known to contain slate of a marketable quality, number four or five.

In the Monson district the operating quarries are all located within three miles of the town. The striking and unique feature of these veins is their narrowness and the vertical cleavage of the slate.

### HISTORY OF THE COMPANY

The latest quarrying company in the field, and the one to which these notes particularly refer, is the Portland-Monson Slate Co., with general offices at Portland, Maine. Although inaugurated only about five years ago, this enterprise has made rapid strides and is now one of the largest producers in the district. The first shipment of slate from this plant was in March, 1907. At the present time, the company is operating four quarries, and a large mill. A large building for the storing of roofing slate, a mill, a compressor house, an office building, boiler house, powder magazine, stables and other smaller buildings,



Sullivan Drill and "VX" Channeler at the end of the pit.

together with a large earth dam for water storage, comprise the surface equipment.

The Portland-Monson vein has an average width of 20 feet and has been opened up for a length of about 600 feet along the strike. Natural partings in the deposit, known as bed joints and head joints, (see the photograph, page 546) greatly facilitate economical quarrying. While there is no regularity in this jointing, the average distance between the horizontal bed joints is about ten feet, with very rarely a bed as thick as 15 feet.

The stone from this vein is of a permanent black color, is fairly hard and exceptionally strong. Its most valuable property, however, lies in its absolute freedom from pyrites, magnetite, and metallic threads, any of which would prohibit its use for electrical switchboards.

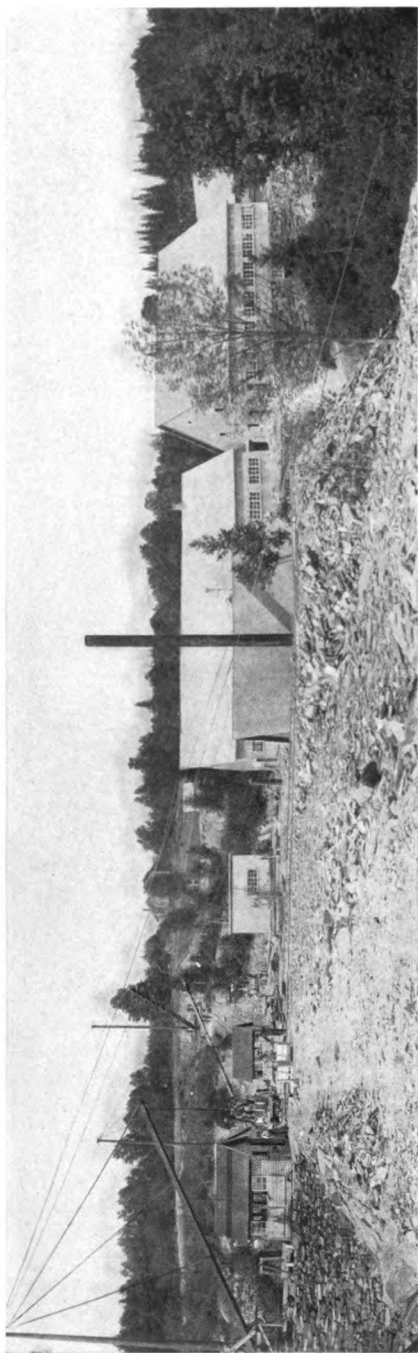
#### QUARRIES

The Portland-Monson Company is at present operating four quarries, one of

which is a new pit, which was stripped this spring. In this, four benches have thus far been quarried. The remaining three quarries have an average depth of about 150 feet, an average width of 20 feet and a total extension along the vein of 500 feet. In addition, a tunnel cut has been run in from one of these pits a distance of 70 feet. A realization of the peculiar problems to be solved in quarrying Monson slate can be gained by referring to the photograph on page 545. The narrowness of the vein and the vertical dip and cleavage create quarrying difficulties which require considerable ingenuity for their solution.

#### EARLY METHODS

For years a certain standard method of working has been followed in this district, which, although it involved many serious disadvantages, was considered, until recently, the only practicable one. A rock drill put in a series of holes at one



end of the quarry, down to the next bench. These holes were loaded heavily with dynamite and fired electrically from the bank of the quarry, forming a "sink" which gave a second free face. The "opening vein," near the south wall, formed the next point of attack. This vein was drilled and blasted out with heavy charges, forming a third free face. After cleaning out the *débris* from these two cuts, the good slate was wedged out and hoisted. Perhaps the only advantage which can be claimed for this method is its simplicity; while its disadvantages are very serious ones.

One disadvantage lies in the fact that an important percentage of the valuable slate is broken or damaged by the heavy blasting. Another difficulty lies in the peculiar structure of the side walls surrounding these veins. It will be seen readily that such walls, made up as they are of slabs of rock standing on end, have little natural stability. Several quarries have experienced heavy slides of this wall rock, either wiping them out completely or subjecting their owners to great expense in cleaning out the *débris*. It is self-evident that heavy and frequent blasting, which forms a part of this old method of working, is disastrous in its effect on the walls, aside from the cost of the dynamite. Add to this, the fact that this heavy blasting shakes up or fractures approximately 25 per cent of the commercial slate in the vein.

#### INTRODUCTION OF CHANNELERS

During the development of these quarries, the management used the method described above, but with a full realization of its crudeness. About a year ago, the company took a step which was considered radical, in purchasing a Sullivan "VX" channeling machine. Channelers have been used for many years in the slate quarries of Pennsylvania, Vermont and Arkansas. In these fields the beds are tipped less sharply, and quarry methods approach more closely those employed in

the marble and building stone fields. The channelers are employed chiefly because they reduce to a very large degree, the waste caused by drilling and blasting.

The advantages gained from channeling in Pennsylvania slate quarries were described in *MINE AND QUARRY* for May, 1907, by Mr. Arthur E. Blackwood.

It would be natural to suppose that the advantages of channeling would appeal especially to Monson quarry men. In addition to saving a large amount of marketable slate, the elimination of blasting means that the stability of the side walls, and with it the existence of the quarry, are not endangered. Nevertheless, long standing ideas proved hard to displace, and the channeler of the Portland-Monson Company was the first to be consistently tested and placed in permanent use. This machine was successful from the start, and two more Sullivan "VX" channelers have been purchased since that time. The amount of blasting done is comparatively small.

The company secures the following advantages from this new method of quarrying; the quarrying cost per foot of slate has been materially reduced, while production is more rapid than before; the outside or quarry crew is able to work continuously, instead of losing part of a day or a whole day in each week, while blasting is going on. The quarry pits are much safer to work in than before, and powder has become an incidental expense instead of a principal one. Practically no slate of commercial value is wasted over the dump.

In opening a new pit or starting work on a new level, the channeler cuts across the quarry end, down to the next bench or bed in the slate. This cut forms an artificial head joint. The valuable slate is next channeled lengthwise of the pit and wedged off. The photograph on page 546 shows a channeler cross-cutting in the foreground, and a second machine in the rear, cutting lengthwise.

The "VX" machines cut as deep as 16 feet, if necessary, and on straight work and

runs of 15 feet or more, average fifty square feet of channeling per ten-hour shift. They are so light and compact that they can be handled readily by the quarry derrick, and set anywhere that work is to be done. One of the rails of the channeler track is provided with a rack, to fit corresponding gears on the drive wheels. The machine works smoothly and without danger of running away, on grades up to 30 degrees.

One reason for not adopting channelers in this field earlier has been the objection to steam in these deep, narrow pits, more like mine shafts than quarries. Even when drills were used altogether, clouds of exhaust steam hung in the pit and obscured the work.

The Portland-Monson Company installed a Sullivan Air Compressor about



Sullivan Channeler 150 feet from the surface.

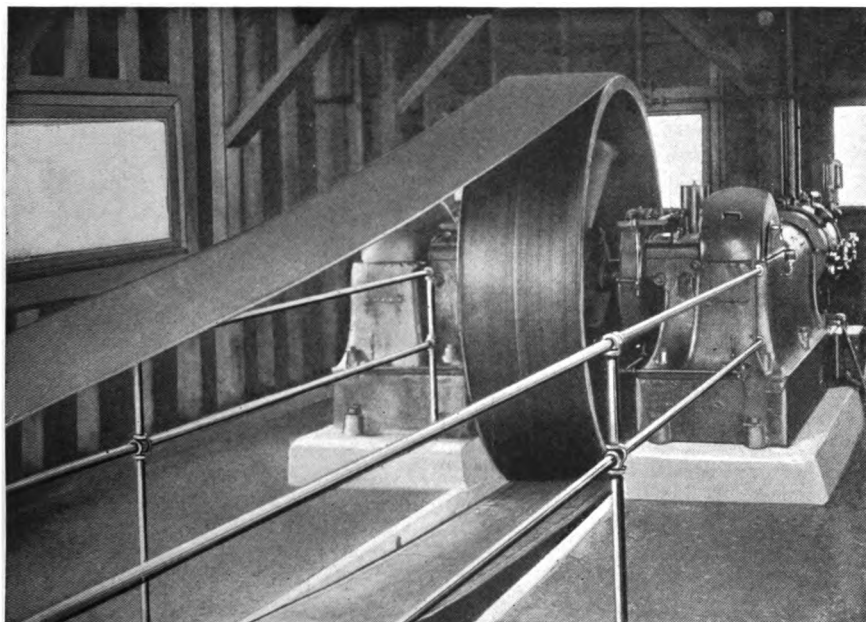


Sullivan "VX" Channelers at the new opening. Portland-Monson Slate Company.

two years ago, and the three channelers, two Sullivan Rock Drills, and one Sullivan Hammer Drill, as well as three pumps and two hoisting engines, are all operated by air power at a pressure of 90 pounds to the square inch. Air has the further advantage over steam, that its efficiency is but little impaired in conduction through long pipe lines. The waste in forcing steam through exposed pipes, particularly in winter, is considerable. To secure the best possible efficiency, and to prevent freezing, the air is run through Sullivan reheaters, of which there are three, before it reaches the drills or channelers.

The Sullivan Hammer Drill, mentioned above, is of the "DB-19" hand-feed pattern, using hollow steel, and puts in blast holes up to five feet in depth.

Another unique feature of these quarries is the system of reinforced concrete braces which are put in to sustain the heavy pressure of the side walls. The core is formed by heavy structural steel "I" beams and still greater strength is secured by the conventional helically twisted rods. Additional security against slides is provided by two dry walls of waste rock which were laid up last winter. Heavy cross-timbers are put in where needed, to



Sullivan Two-Stage Compressor, Portland-Monson Slate Company.

provide against local scaling. (See photograph on page 545).

The slabs of mill stock are chained and hoisted by the derrick, dropped onto platform cars on a narrow-gauge track and pushed into the mill. The rubbish is loaded into boxes, hoisted and loaded on dumping platform cars, on which it is run to the edge of the dump.

#### MILL

At the mill, quarry stock is split by wedges to the proper thickness, and cut to the dimensions required by a circular saw, the saw table being self-feeding. The slab is next put on a planer, where the surfaces are smoothed up and it is brought down to exact thickness. The finishing is done on a rubbing bed, which consists of a twelve-foot rotating cast iron disc, on which is fed beach sand and water: and a final polish is given by rubbing. The stock is beveled by a carving tool such as is used by granite cutters.

#### POWER PLANT

The Sullivan Air Compressor, above mentioned, is shown on page 547. It is of the duplex, two stage pattern, class "WJ," with air cylinders 20 and 12½ inches in diameter, and 16-inch stroke. This machine gives a displacement capacity of 873 cubic feet of free air per minute, at 150 revolutions. The inter-cooler is of liberal cooling area. The compressor is rendered practically automatic by a combined bath and gravity system of lubrication for the main working parts, and by an unloading device on the air inlet duct. It is driven by belt from a 125 horsepower electric motor.

The entire plant is operated by electricity, supplied by the Greenville Light and Power Company from a hydro-electric plant at Greenville, 14 miles from Monson. The voltage on the main power line is 16,000, which is stepped down to 2,080 volts at the quarry. The mill is operated by a 50-horsepower motor, and

one derrick is operated by an electric hoisting engine. The old steam plant, formerly used, is now held in reserve for use in case of trouble with the electric power. Among other operators in the district are the Maine Slate Company of Monson, and the Monson Maine Slate Co.

Acknowledgment is hereby tendered to Mr. John W. Coleman, Portland, Maine, President of the Portland-Monson Slate Company, and Mr. George Wilkins, Superintendent at Monson, for photographs and other assistance in the preparation of these notes.

### COAL AND IRON IN ALABAMA

A book which has made a place for itself in industrial literature is the "Story of Coal and Iron in Alabama," a narrative of the mineral development of the South which has been issued under the auspices of the Birmingham Chamber of Commerce.

This work covers 581 pages, octavo, and within its covers comprises the complete history, from the beginning, to the present time of coal and iron ore mining, of blast furnace construction, of iron and steel making, and of transportation not only in Alabama, but in neighboring states in the South.

Sketches of pioneers, state geologists,

railroad men, civil and mining engineers, military men and iron masters and coal operators are included. The work is not only thorough and authoritative, but the subject matter has been handled in a most attractive and readable manner by the author, Miss Ethel Armes, who spent some three years in preparing the work for the press. The publication is handsomely bound, contains numerous illustrations, and should be on the library shelves of all who come in touch with the mineral and manufacturing industries of the South.

Copies may be obtained from the Bienville Publishing Co. of Birmingham.



Sullivan Diamond Drills testing for bed rock at the site of the Rio Concho Dam.

## NOTES ON DIAMOND DRILLING IN MEXICO

The accompanying photograph shows a Sullivan Class "E" Diamond Core Drill in a peculiarly difficult situation.

The drill is at work on the El Refugio Mine, about 15 miles from Salinas, State of San Luis Potosi. This district, like many others in Mexico, has, in the distant past, been subjected to great disturbances, and the rocks are severely twisted and fractured. Large faults have occurred in many localities, distorting the mineral lodes, and sometimes occasioning much difficulty in picking up, at lower depths, the values which have been proved in the upper levels.

For testing work of this sort, the diamond core drill is of great assistance on account of the rapidity with which the country can be exploited. Another advantage is, that there is no limit to the inclination at which holes may be bored. The drill is shown in position on the side of an arroyo, or deep ravine, which is the surface effect of a great vertical fault. In this case the walls stand perpendicular, and are between two and three feet apart.

The general dip of the rock is about 45 degrees to the east, so in order to cut the strata at right angles to the inclination, thus securing a core of the greatest possible number of layers, with the shortest possible length of hole, the drill is tilted at an angle of 45 degrees to the west. This hole was drilled to a depth of 400 feet. The drill is operated by steam, from a portable boiler. The transportation and installation of this boiler involved no mean engineering difficulties, as the mountain passes are very rugged and steep and unceasing caution was required to prevent the outfit from capsizing into one of the deep arroyos along the trail.

During the last 500 yards of this journey, the boiler had to be carried on skids. The contractors, The National Drilling Company, S. A., of El Oro, Mexico, have



A difficult "set-up." Sullivan "E" Diamond Drill at El Refugio Mine.

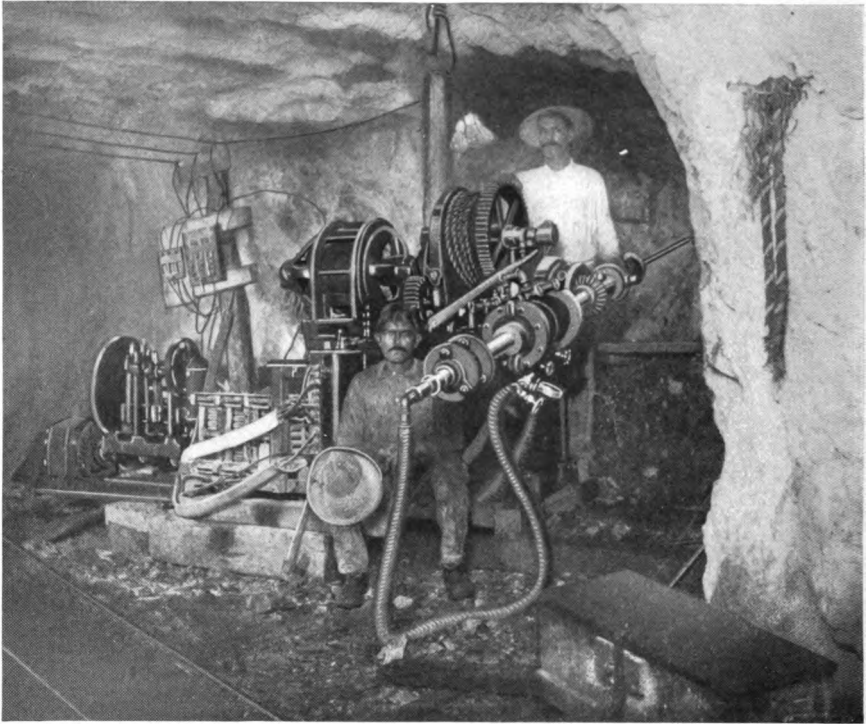
about 2,000 feet of this work on the El Refugio Mine.

The editor's thanks are due to this company for above information and the interesting photograph shown.

UNDERGROUND DRILLING<sup>1</sup>

In the Lluvia de Oro Mine, in Chihuahua, a considerable amount of underground drilling has been done in the last year. The property of the Lluvia de Oro Gold Mining Company is located near the Sinaloa line, and is accessible only by mule

<sup>1</sup> Abstract of an article by J. N. Buese in Salt Lake Mining Review.



Sullivan "RH," 1000-foot Electric Diamond Drill, boring a hole 15° above horizontal in the Lluvia de Oro Mine.

back travel. Fuerte, Sinaloa, the nearest railroad point, is three and one-half days' ride away.

The presence of very hard rock and the necessity of drilling by hand made exploration by drifts and tunnels prohibitive in price. The company therefore decided to purchase a diamond core drill, capable of drilling at any angle. Ample electric power is available from the company's hydro-electric plant, nine miles from the mine, on the Fuerte river.

A Sullivan class "RH" electric driven outfit with single cylinder hydraulic feed was selected. This has a capacity of 1,000 feet in depth, and removes a core  $\frac{1}{8}$  of an inch in diameter. The motor is of the direct current, variable speed induction pattern, wound for 440 volts and developing ten horsepower. A bit speed of from

200 to 1,500 revolutions per minute may be obtained by varying the field resistance on the motor, through a controller and rheostat, and any speed within these limits may be maintained without undue heating of parts.

The pump for feeding water to the drill rods and hydraulic cylinder is a 3 x 3-inch triplex, and is operated by a five horsepower motor. It is equipped with a release valve which can be set for any desired pressure, and opens, automatically, when the point for which it is set is exceeded. A constant pressure is thus available for the hydraulic feed.

The drilling was all done in the Cuauhtemoc Tunnel, from stations cut at the desired points. For horizontal holes the stations are 11 x 13 by six feet high, and are shorter and higher when down holes

or uppers are to be drilled, the size depending on the angle of the proposed hole. The photographs on the front cover and on page 550 show the drill outfit, with motor, pump and other fittings.

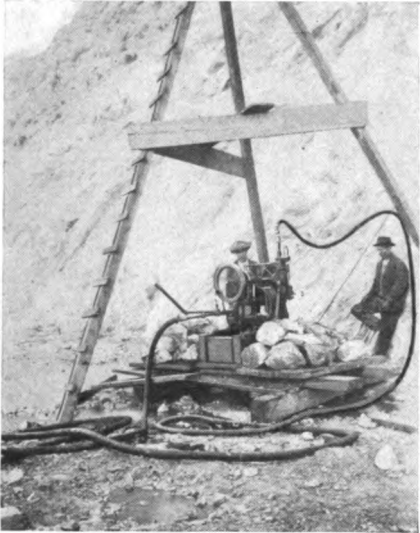
When the drilling was begun, water was very scarce; a winze, about 15 feet deep, was the only source of supply, and gave five gallons per day. As more water became necessary, a settling tank was employed. The water from the drill hole was diverted into this tank, allowed to settle, and used over and over again. The only losses were through fissures in the rock and in cleaning out the borings caught in the riffles of the tank.

The first hole bored, however, struck a fissure at a depth of 246 feet, which gave a constant flow of 20 gallons per minute, thus settling the water question.

The rock drilled was chiefly a hard and broken diorite. The ore is a greyish quartz, very hard when low in mineral, but softer and oxidized when rich. Some limestone was also encountered, which drilled very nicely. The average drilling in limestone per shift was 27 feet. In diorite, the speed fell to twelve feet, and in ore, to five feet per shift.

An American drill foreman and Mexican runners and helpers were employed. The foreman set the bits and ran the drill also in some of the broken ground. Drill runners are paid \$3, Mexican, and helpers, \$1.50 per day.

The picture below shows one of the



Sullivan "S" Diamond Drill at Rio Concho.

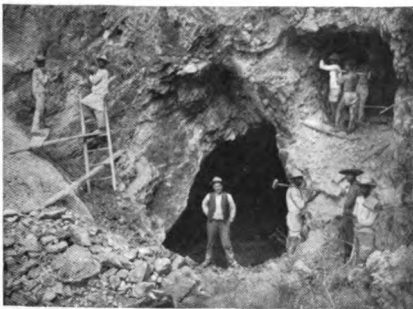
openings leading into the mine. The Mexican miners are good hammer men, and a team of two will average four to five feet of drilling, in the ore, per ten-hour shift.

#### TESTING DAM FOUNDATIONS

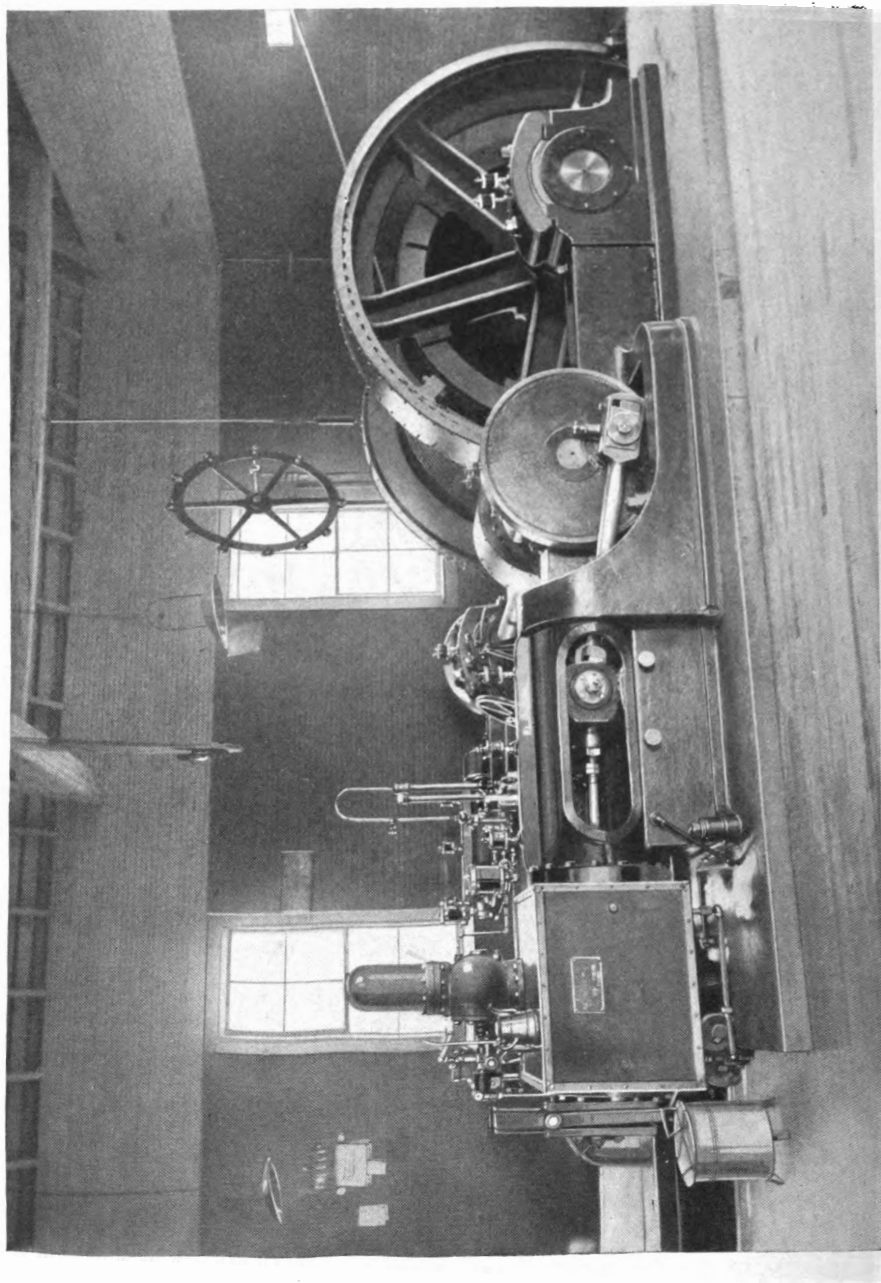
Diamond Drills are also used in the republic for coal prospecting and for engineers' test borings. The photograph on page 548 shows two class "S" 500-foot Sullivan Core Drill outfits, in work of the latter description.

S. Pearson & Sons, of London, England, are constructing a water power dam on the Concho River, near Camargo, in Chihuahua, for the Compania Agricola de Fuerza Electrica de Rio Concho. The site of the dam was first unwatered by means of cofferdams. The ground thus exposed was then thoroughly tested with the diamond drills above mentioned, to determine the exact location and nature of the bed rock.

The average depth of the holes bored was 30 feet, but seven holes were put down to a depth of 100 feet each, to verify the



Hand drilling at the Lluvia de Oro Mine.



Sullivan Automatic Slide Valve Hoist at a Lake Superior iron mine.

continuity of the strata. The total amount of the diamond drill borings was over 3,600 feet. As usual in soundings of this class, standpiping was driven through the overburden in the bed of the river, and the diamond bit brought into play when rock was reached. The

core removed was about one inch in diameter.

The dam is of reinforced concrete. It will store water for irrigation purposes in the adjacent country, and also afford electric power which will be transmitted to mining camps such as Naica, in the vicinity.

## HOISTING ECONOMY FOR SHALLOW MINES

By S. T. NELSON<sup>1</sup>

A trip of inspection and observation made several years ago through the iron ore fields of northern Minnesota, impressed upon the writer's mind the large number of mining companies that were hoisting from comparatively shallow depths with primitive slide valve engines of the poorest fuel economy.

The thought occurred that some means might be devised for doing this work at a much lower cost for coal. When "automatic cut-off" was mentioned to users of these hoists, the answer was made that it did not pay to use a hoist equipped in this way in shallow mines, and it was almost impossible to convince them that an engine of higher economy could be used for these conditions than these slide valve engines, designed and arranged in the same way as 100 years ago. The engineers of the district, in fact, adopted the attitude of the man from Missouri. The challenge thus offered was taken up, and this article will indicate whether or not they have been "shown."

By shallow mines are meant those from 200 to 1,200 feet deep. The average load handled, exclusive of the rope and skips, is five tons, and ordinary service requires a speed of 700 to 1,000 feet per minute, so that a load will reach the surface once a minute from a depth of 1,000 feet. With these conditions in mind, a glance at the general development of equipment for lifting ore from mines, will be worth while, and will indicate the experience available

to the engineers in designing hoists for these conditions.

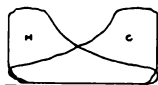
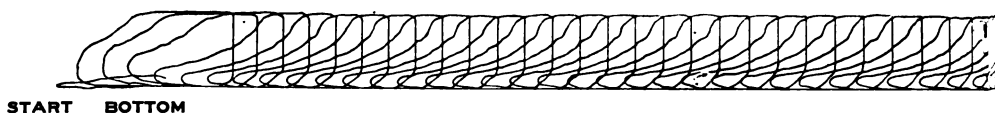
### DEVELOPMENT OF CORLISS HOISTS

Some 30 years ago, Corliss engines, or engines with an automatic cut-off, were just being introduced for hoisting purposes. These new plants were chiefly in the copper district of the Lake Superior field. They consisted largely, of regular mill engines, purchased from the Corliss engine builders; some were furnished with gears and pinions and some were not. The drums were built up at the mine, nearly all from wood.

With these exceptions, the hoists then in use were equipped with slide valve engines of the commonest type. Crude as were the first Corliss hoists, and numerous as were the objections and jibes cast at them on account of their "trappy" and "complicated" mechanism, the reduction in fuel consumption which they secured by means of the automatic cut-off was so great, that the slide valve engine was soon crowded from the field.

The iron companies of the northern Michigan field were also impressed with the fact that Corliss hoists did their work on from one-third to one-half the fuel required for the slide valve pattern. The first engines installed at any of the iron mines with a detachable valve gear for automatically closing the steam valves were not of the Corliss type, but of the same type as an engine that is still built at Fitchburg, Mass., by the Brown En-

<sup>1</sup> 2624 West Lake St., Chicago.



Continuous indicator diagram from Sullivan Automatic #

gine Company. A modified type of the Brown engine was adopted by one of the hoisting engine manufacturers of that time, and several of them installed. These engines were found to be very satisfactory and were economical on low steam pressures. However, they did not lend themselves so successfully as the Corliss pattern to the constant increase in steam pressure, which took place with improvements in boiler manufacture.

#### STANDARD FOR DEEP MINES

From this time the Corliss engine became the standard for deep hoisting practice throughout the Lake Superior region and the western mining fields as well. By deep mines are meant those ranging from 1,000 to 5,000 feet in depth. It may be said, in passing, that the M. C. Bullock Manufacturing Co. and its successors, the Sullivan Machinery Co., took a leading part in the development of this class of hoisting machinery.

With the knowledge and experience gained in designing hoists for deep mines at their command, the engineers of the company attacked the problem of securing hoisting economy for shafts of more moderate depths.

It is out of the question to use first motion Corliss hoists for this work, on account of the limitations in speed of Corliss valve gear requiring engines unduly large for the service required. In shafts only a few hundred feet in depth, after

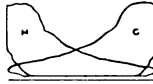
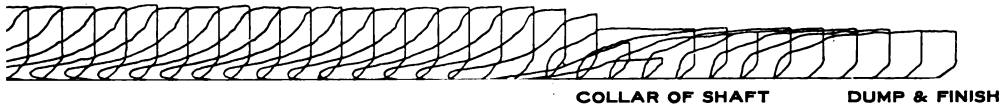
the load is accelerated, but few revolutions of the engine will be made with the automatic cut-off in action, so that a direct acting Corliss plant would be not only needlessly high in first cost, but more extravagant in fuel than a slide valve engine of the simplest type.

Corliss geared hoists were tried for some of these shallow mines, but as in the case of first motion plants, engines disproportionately large had to be furnished, to keep the number of revolutions as low as possible. Difficulty was also incurred in certain fields, in securing engineers that would and could take proper care of a Corliss engine; so that mine managers continued to use the old-fashioned, plain slide valve hoists, with their excessive cost for fuel.

#### THE AUTOMATIC CUT-OFF ON SLIDE VALVES

After much study, the type of hoist known as the Sullivan automatic slide valve hoist was worked out, and has now been in satisfactory use for several years. That this design fulfils the conditions described in the first paragraphs of this article, will be seen readily from a study of the illustration on this page. This is an exact copy, reduced in size, of a continuous indicator diagram taken from the hoist of this pattern at the Webb mine of the Shenango Furnace Company, at Hibbing, Minnesota.

The hoist consists of two slide valve engines, each 16x18 inches in size, geared



le Valve Hoist at the Webb Mine, Hibbing, Minnesota.

to a single drum six feet in diameter by six feet long. It takes steam at 145 pounds, boiler pressure, and runs at 140 revolutions per minute, hoisting a load of five tons of ore in addition to the weight of the rope. Two skips are used in balance so that their weight is offset.

#### A GRAPHIC "ECONOMY" RECORD

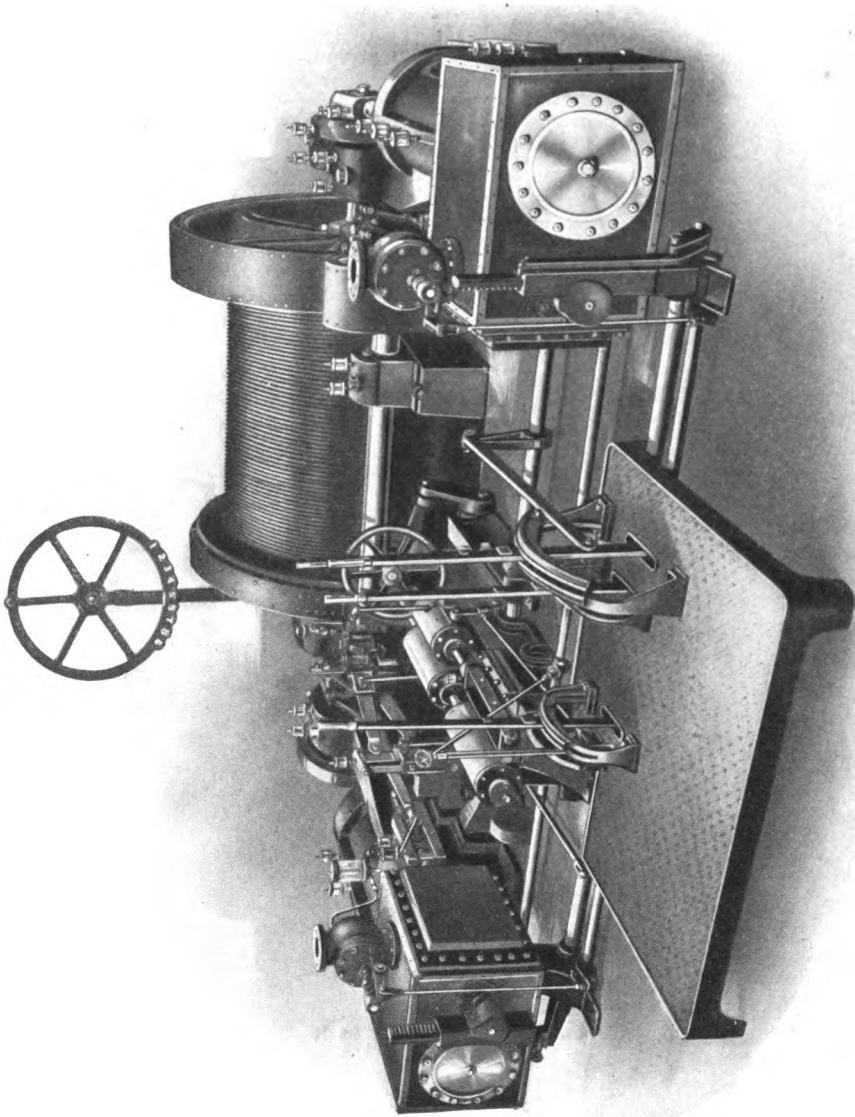
The diagram represents the entire trip from the start at the bottom to the dump. Each diagram indicates one revolution of the engine. The gear and pinion ratio is four to one, so that the engines make four revolutions to one of the drum. As there are 57 diagrams, the depth of the shaft is 269 feet and the load is hoisted in 14 revolutions of the drum.

In starting from the bottom, it should be noticed that the first diagram takes steam three-fourths of the stroke, the second about five-eighths of the stroke, the third about one-third of the stroke; at this point the acceleration is completed. From there on, up to the point referred to as "collar of the shaft," the engine is cutting off at about one-fifth. At this point attention is called to the drop in pressure, as indicated by the diagram, and the length of admission of steam to the cylinder. When this point is reached, the engineer closes the throttle partially to slow up for the dump; this puts the automatic cut-off out of action, in precisely the same manner as the dashpots cease to drop when a Corliss engine is being re-

tarded. From the point called "collar of the shaft" to the point referred to as the "dump and finish" the regular slide valve action is secured, just as would be the case for the entire distance from top to bottom were it not for the automatic cut-off.

The three individual cards, below the continuous diagrams, were set aside so that users of engines not familiar with continuous diagrams can tell from these the action of the valve gear and the steam distribution. Although these cylinders are only sixteen inches in diameter by eighteen-inch stroke, the diagrams are as perfect as though they were taken from a Corliss engine having cylinders 24 x 48 inches or 30 x 60 inches. The slightly jagged appearance of the lines is due to the high speed at which the engine was running and to a small amount of water in the indicator pipes, which caused the indicator pencil to chatter.

It should be noted that in hoisting engines, hand adjustment of the point of cut-off is out of the question. It would require an engineer's constant attention, to give his engine steam for the entire stroke when starting the load; to set the valves at the proper point of cut-off when the load is under full motion, and to lengthen the cut-off again, at the end of the trip. This is obviously impossible, nor would it be possible for the engineer to set the cut-off at its most economical point each time, owing to variations in steam pressure and load.



Sullivan Automatic Slide Valve Hoist; rear view, showing handling motion.

## DESCRIPTION OF ENGINE

The engines of the Webb mine hoist and of others of this type, are of the plain double slide valve pattern, and the valve gear places no limit on the speed at which they can be run. The mechanism controlling the automatic cut-off is so arranged that no extra thought or action is required of the engineer.

When the throttle lever is pulled, the first two or three inches of its movement opens the main throttles, admitting steam during the entire stroke to start the load from the bottom, as shown by the first cards. As the lever is pulled back, it admits steam to an auxiliary valve mechanism and cylinder, shown just to the right of the brake engine in the cut on page 556. The piston of this cylinder actuates a crank and shaft, which in turn moves the vertical rack shown at the rear end of each cylinder. These racks engage pinions, one at the outer end of each cut-off valve stem. The admission of steam to the auxiliary cylinder therefore automatically places the main valves in the position of shortest cut-off, and this action is shown in the cards as above described. At the end of the trip, the reversal of the lever, to close the main throttles, admits steam to the opposite side of the piston on the auxiliary cylinder, and the cut-off is restored to its first position.

As stated above, no attention to the cut-off mechanism is needed, after the eccentrics have been set, to secure the most economical operation possible with the service factors of steam and load pressure which are prevalent. The slide valves are operated by separate eccentrics, with the usual link motion, the third eccentric shown being for the cut-off. The range of the cut-off is from three-quarters to one quarter at the latest set-

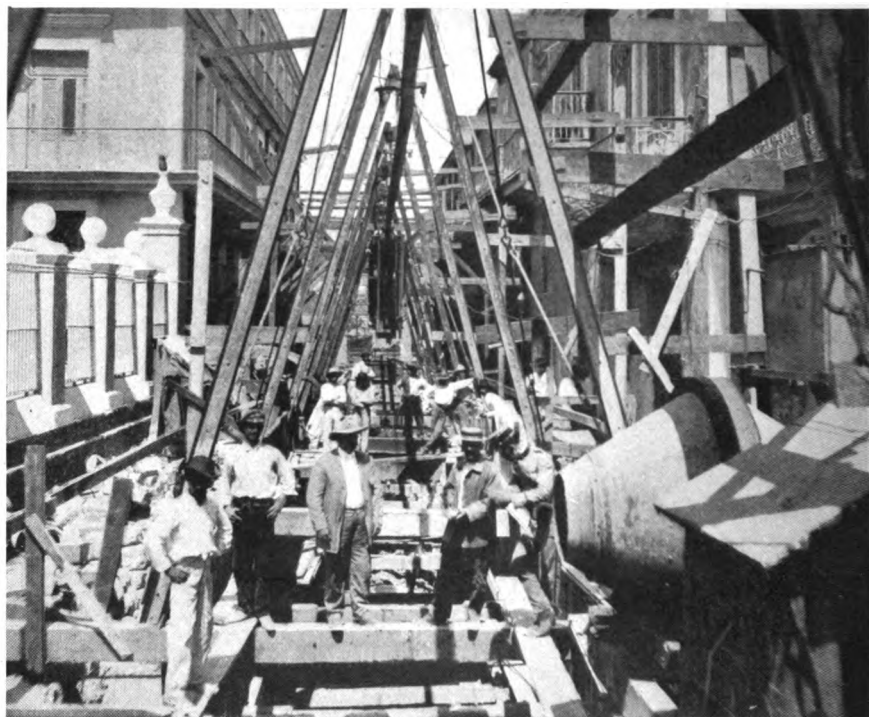
ting, and from four-tenths to one-tenth at the earliest.

The hoists embody the most modern practice in all details. The engines are reversible, by a standard hand-operated link motion. The drum is keyed to the shaft. The brakes are thrown by steam, with a hand wheel for use when the plant is not under steam. The gear is of semi-steel, and the pinion is made of cast steel, with cut teeth of the short involute pattern, rendering the action of the hoist smooth and quiet.

These hoists have been installed in a number of the Lake Superior iron mines, and have given excellent service, thoroughly demonstrating their high fuel economy in handling the heavy iron ore business of the Mesabi and similar ranges. They are well adapted for the mines of the western states and Mexico, where fuel is expensive.

They are built in stock sizes, with drums from six to eight feet in diameter, and engines ranging from 14 x 14 to 16 x 24 inches, adapted for 150 pounds steam pressure. The hoisting speeds range from 700 to 1000 feet per minute and the loads from five to seven tons.

The Webb mine is expected to be one of the largest shippers next year, among the underground mines on the Mesabi range. The power plant includes new modern high pressure boilers, a five-drill air compressor, and new direct current electric generator. The new head frame is of steel, and the power house is of steel and brick, with a large brick stack. Underground electric haulage is planned for serving the No. 2 shaft, and development is progressing rapidly. The old shaft is used as a raise to serve the different levels. About ten cars of ore per day are being shipped over the new Great Northern spur.



Building a sewer in place.

### PORTABLE ROCK DRILLS ON THE HAVANA SEWER

*(Contributed)*

The city of Havana, Cuba, is at present engaged in installing a complete sewerage and drainage system, which covers 300 miles of streets. Together with the paving of these streets, after the sewers are installed, the amount of the contract is \$16,500,000 and the undertaking is the largest one of the kind which has ever been conducted on a single contract.

Plans for a modern sewerage and paving system were drawn during the Spanish rule; a contract was in fact entered into by the Spanish authorities with Col. Michael J. Dady of Brooklyn, but owing to the revolution, the contract was never carried out. Under the Platt amendment to the treaty of Paris, the United States Government undertook to be responsible

for the sanitation of Havana, as a matter of protection to the southern ports and to the ports of the world at large.

During the term of administration of President Palma, plans were again drawn and a contract let, but no work was accomplished because of failure to appropriate funds for the purpose. In the meantime, the problem grew, as the population had increased something like 50 per cent in the ten years following United States intervention. In 1908 the provisional governor, at the direction of the authorities at Washington, issued a decree setting aside 10 per cent of the customs duties for sewer and paving work, and later a bond issue amounting to \$16,500,000 was authorized by the Cuban

congress, in the first session after the second intervention, to provide funds for carrying out the work immediately. By this means it is estimated that the enterprise will be completed in four years' time.

The present contractors for the construction of the sewers and drains, constituting 52½ per cent of the entire enterprise, are the Cuban Engineering and Contracting Co., a concern which was organized for the purpose by the officers of the United Engineering and Contracting Co. of New York. The paving contract is held by the Uvalde Asphalt Paving Co., also of New York. Preliminary work was begun in the fall of 1908, but construction on a large scale was not begun until a year and a half later.

The general plan for taking care of the city's sewage consists of two marginal trunk line sewers seven feet in diameter, into which all the branch sewers run and which unite in a siphon tunnel, which crosses the harbor and empties into a screen chamber at the main pumping plant near the Cabaña fortress, in the locality of Casa Blanca. From the pump chamber the sewage is lifted 24 feet and flows by gravity to a concrete lined tunnel seven feet in diameter skirting Cabaña Hill; it is then carried by a cast-iron outfall pipe to a point 550 feet offshore, where it is emptied into the Gulf Stream in water 30 feet deep, where the stream has an average current of four miles per hour. The sewage is thus carried away from the harbor and out to sea.

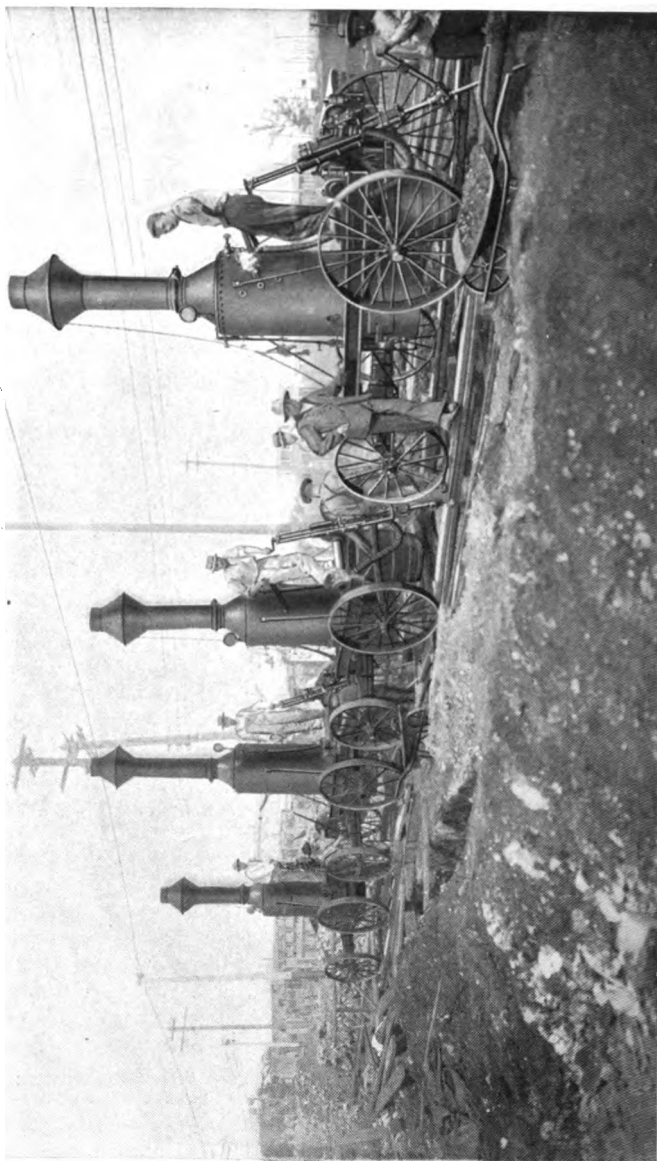
Numerous difficulties have been encountered and overcome in the prosecution of this work. Many of the streets are narrow and it was necessary to devise special means for constructing the sewer rapidly so as not to block traffic longer than necessary. For this reason reinforced concrete pipes with lock joints are used almost altogether and placed in position by means of an ingenious system of monorail telfer tracks, as shown in the illustration on page 562.

#### ROCK EXCAVATION

A large amount of rock excavation has been necessary in the coral formation. The rock was of very irregular occurrence, in some places requiring excavation to a depth of only four feet, in others, fourteen to sixteen feet. Rock so soft as to be easily worked with a hand pick is intermingled with rock as hard as flint; much of it breaks up like slag, while some is as tough and sticky as copper ore.

For work under these unusual conditions, drills were necessary which would have sufficient capacity to drill to the greatest depth necessary, removing the rock in a single lift, and at the same time sufficiently portable to be easily and quickly moved from place to place and able to operate with fair economy when only a small amount of drilling was necessary. The illustrations on page 560 and 561 show the outfit which was designed and built for this purpose by the Sullivan Machinery Co., in accordance with the requirements and suggestions of Mr. P. G. Brown, Vice-president and consulting engineer. The drill employed is the type UF-11 with 3¼-inch cylinder, capable of drilling to a depth of 16 feet with a bottom gauge of 1¼ inches. This drill is equipped with the Sullivan tappet valve motion, which is particularly adapted to rock of the varying kinds encountered. This valve motion secures great pulling power, which is of high importance, in sticky rock, and yet is capable of delivering a blow of great strength and snap when hard rock is to be drilled.

The drill is mounted on a heavy steel bar by means of a column saddle and this bar in turn is set at the rear end of a wagon truck made up in an A-form of channel irons and steel wheels. The truck carries a 12-horsepower vertical boiler adapted for burning either coal or wood. The stack is hinged, to permit passage under viaducts. The tread of the wheels is six feet. In case the sewer trench is wider than this, a staging of boards is made for the outfit to run on. When nec-



Four Sullivan Portable Drill outfits on the Havana sewer.

	No. Holes	Total Depth feet.	Average Depth feet	Drilling min.	Changing Steel min.	Moving Drill min.	Moving Machine min.	Total Time min.
Drill No. 1, total Av. per ft....	6	75.5	12.3	243 3.2	179 2.4	85 1.1	42 0.6	549 7.3
Drill No. 2, total Av. per ft....	6	85	14.2	241 2.8	155 1.8	30 0.4	53 0.6	479 5.6
Drill No. 3, total Av. per ft....	10	134.5	13.45	404 3.0	178 1.3	23 0.2	33 0.2	638 4.7
Drill No. 4, total Av. per ft....	18	71	4	172 2.4	86 1.2	77 1.0	220 3.1	565 7.8

essary to secure additional stability, a timber can be laid across the trench and the special supports or jacks used to lift the wheels off the ground and throw the entire weight of the outfit on to the jacks, thus making a firm and rigid bearing for the drill.

The drill is furnished with steam from the boiler, by means of steel pipe with flexible joints or by steam hose wound with marlin. The entire outfit weighs about 5000 pounds. There are now ten of these outfits on the work, and they have given very satisfactory service.

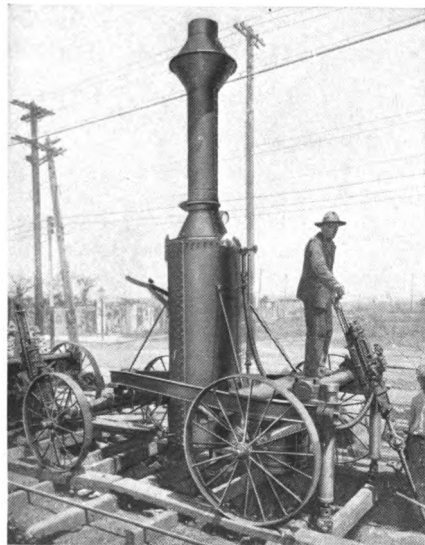
The herewith table will show the way in which the machines were handled, and the amount of work done per day, etc. The heading, "Moving Drills," is the time occupied in moving the machines along the bar or mounting. The heading, "Moving Machines," is the time moving the outfit from one point to another on the sewer.

With the exception of the rock drills the plant is operated electrically. The advantages of electrical operation are accentuated in Havana, where the streets are so narrow that there is little room for setting up the usual boiler and engine for operation of concrete mixers, etc., and where the annoyance from smoke and noise would be a severe tax on the patience of the householders. In driving the tunnel under the harbor, no great difficulties have been experienced. It will probably sound odd to tunnel diggers to say that

conditions were met under Cabaña hill, where rock was encountered in the roof of the tunnel and earth in the bottom, and that this condition existed for a material distance, but such was the case.

About 200 miles of sewer work have already been completed and this portion of the enterprise, as well as the paving, is proceeding rapidly and smoothly.

We are indebted to Mr. P. G. Brown of the Cuban Engineering and Contracting Co. for photographs of the drills at work and for the tables quoted above; and to Engineering Record for the other



A closer view of a drill rig.

pictures and a portion of the general description. A more complete description

of the work will be found in Engineering Record for September 30th.



#### EXTRACTS FROM A DIAMOND DRILLMAN'S LOG.

When drilling for rock salt in Louisiana some years ago, it was found that the length of core recovered in passing through the salt deposit was greater than the thickness of the deposit, as shown by the length of rods used in the hole. Investigation showed that each run of core stretched or expanded from one to two inches after it was removed from the core barrel.

Drilling in cold countries affords many unusual circumstances and conditions which must be overcome by the operator. A diamond drill which was operating in Siberia, was delayed for three or four days, waiting for more rods. The hole at that time was about 400 feet deep. When the new rods arrived, and work was resumed, it was found that the hole was frozen solid from top to bottom, and several shifts

were required to break out the ice. This was done by means of a blank bit and the weight of the rods, to which was added water under pressure from the pump. The ground through which this hole was bored was frozen to a great depth and the action of the frost in coming out of the core, when brought to the surface, produced some queer effects. Warm water for drilling was secured by making a sump, at one side of the drill shanty, into which the exhaust from the engine was led.

Underground drilling from a tunnel near the Gunnison Pass in Colorado, some years ago, was attended by difficulties by reason of the extreme cold encountered. It was necessary to mix glycerine with the water for the pump in order to keep it from freezing.

## COAL MINING PROBLEMS IN MICHIGAN

By R. B. HOSKEN, B. M. E.<sup>1</sup>

From an economic standpoint, Michigan is a small factor as a coal producing state.

In 1909, its production, about a million and three-quarters tons, placed it twenty-third, below Montana, Arkansas, Utah and Texas. In 1910, the tonnage was reduced to 1,473,874, and but 2,474 workmen were employed in this industry.

The student of coal mining conditions and methods, however, can well afford the time needed for a closer glance at the Michigan situation than these figures would warrant. With the exception of the very northern part of the Appalachian region, the Michigan coal field is the only one within the drainage area of the great lakes. It covers some 6,500 to 8,000 square miles, the veins having an average thickness of about 21 inches. No coal is mined less than two feet thick at present, and of this there are estimated to be about eight billion tons still unmined. Active mining is confined to the eastern portion of the field, in a line drawn between Bay City and Jackson; and Bay and Saginaw are the two counties in which the bulk of the coal is produced. Small tonnages are credited to Clinton, Eaton, Genesee, Ingham, Jackson, Shiawassee and Tuscola counties.

Coal mining was reported in Michigan as early as 1835; but for many years, wood remained the chief fuel, for both domestic and industrial purposes. It was 1898 before the tonnage rose to the quarter million mark. The maximum output thus far was that of 1907, amounting to a little over two million tons. Development has been slow, and no very great increase can be looked for, owing to the competition encountered from West Virginia and other larger fields. Nearly the entire production of the state is used locally, therefore, and some of the mines operate only during

the fall and winter months, when the domestic trade affords the best prices.

Geologically, Michigan coal seams are correlated with the Lykens Valley group of the Pottsville series and the lower carboniferous formation in Pennsylvania and Ohio. The beds vary greatly in different parts of the field. They lie horizontally, but in some cases, local undulations, called "rolls" or "swamps" are found, which increase the difficulty of mining. The depths of the seams from which the heaviest production now comes, is from 130 to 175 feet. The beds overlying the coal are chiefly weak black shales, making poor roof. Black bituminous limestone, full of shells, or wet sandstone are also found as roof. The bottom is sometimes fireclay, sometimes a soft sandstone. The mines, as a rule, lie beneath low ground and are wet.

The coal itself varies considerably in hardness. In some mines it is soft and friable, breaking up easily. In other portions of the same vein, where the seam is thinner, the coal is much harder, and rolls out in firm blocks, after being undercut.

The vein, which is especially considered in this article, is about 145 feet from the surface. The following is an average analysis:—

Specific gravity .....	1.26
Moisture .....	10.67
Volatile matter .....	33.59
Fixed carbon .....	53.80
Ash .....	1.94
Sulphur .....	1.01
British thermal units .....	13,000

It will be seen from this rough summary, that mining problems and methods will vary in detail in nearly every mine. In general respects, however, the manner of operation is uniform.

<sup>1</sup>Chicago, Ill. 1450 Olive Ave.



The Beaver Mine, near Bay City, Michigan.

#### SYSTEM OF MINING

The mines are opened by double compartment hoisting shafts with an air shaft 300 to 500 feet distant. In this there is a separate man-way or escape shaft with spiral staircase. The underground workings are laid out on the double entry system, with a pillar 18 to 25 feet thick between the haulage road and the air course, which are from eight to fifteen feet in width and from five to six feet high (necessitating brushing the roof and lifting bottom). Cross cuts are made at intervals of 40 or 50 feet. These are closed up and made air tight as the entry advances, to maintain proper circulation of air. Cross entries and air courses are driven at right angles to the main entry, 300 to 400 feet apart. Rooms are turned from the cross entries on 40-foot centers, and in machine operated mines are carried 30 feet wide. They are driven 150 to 200 feet deep, to meet the corresponding room from the next succeeding entry. Breakthroughs for ventilation between rooms are six feet wide, and are spaced not over sixty feet apart. The room necks are eight feet wide. They are kept in good order and especial care is given to the haulage ways.

These are timbered with cross-bars, in the entries, and in rooms, when necessary, to protect them from dropping slate. The curves are carefully laid, to prevent delays to cars or mining machines.

#### VENTILATION

Blowing fans of various patterns are used in the Michigan fields. Slow-speed types are the rule, as the mines are not sufficiently developed to make the ventilation problem a large one. The air current is forced down the air shaft, through the air courses and working places, and back via the haulage road to the hoisting shaft, which is therefore upcast. This arrangement is a convenient one, as it keeps the hoisting shafts free from ice in the winter months. The current is usually reversible, in case of emergency, by opening and closing doors in the fan casing.

#### HAULAGE

The pit cars are of wood, and hold from 750 to 1000 pounds of coal each. (See cut on page 568A). They are pushed to and from the face from the cross entries by hand, and collected in the entries and hauled to the shaft bottom by mules.



The Bliss Coal Company's Mine, Swan Creek, Michigan.

Power haulage has not been generally adopted as yet, because of the small area of the workings. In the No. 2 Mine of the Robert Gage Coal Co. at St. Charles, the trips are hauled from partings on the cross entries to the bottom by electric locomotives. Rope haulage is employed at the No. 5 Mine of the same company, at Auburn. Self-dumping cages deliver the coal direct to shaker screens.

#### MINING

As already noted, mining in this field is handicapped by poor roof, a large amount of water and thin seams, which range from 26 to 42 inches in height. Timbers must be placed at frequent intervals, and brought close up to the working face; and with pumpage represent a heavy charge on the tonnage mined. One mine in particular is obliged to keep an eight-inch discharge pipe running full most of the time, to keep the mine dry enough to be worked.

The pictures illustrating this article were taken in the Beaver Mine, about six miles southwest of Bay City, and at the Bliss Mine, at Swan Creek.

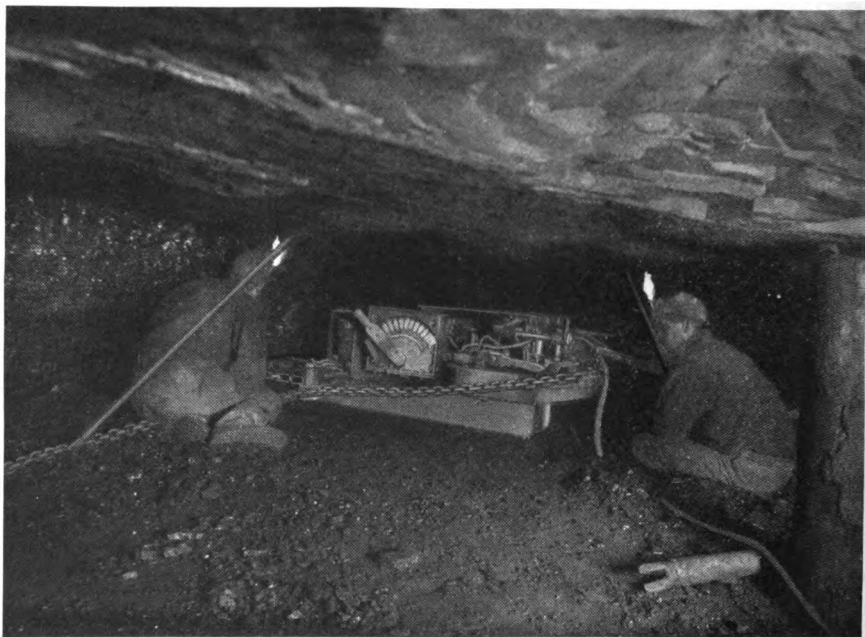
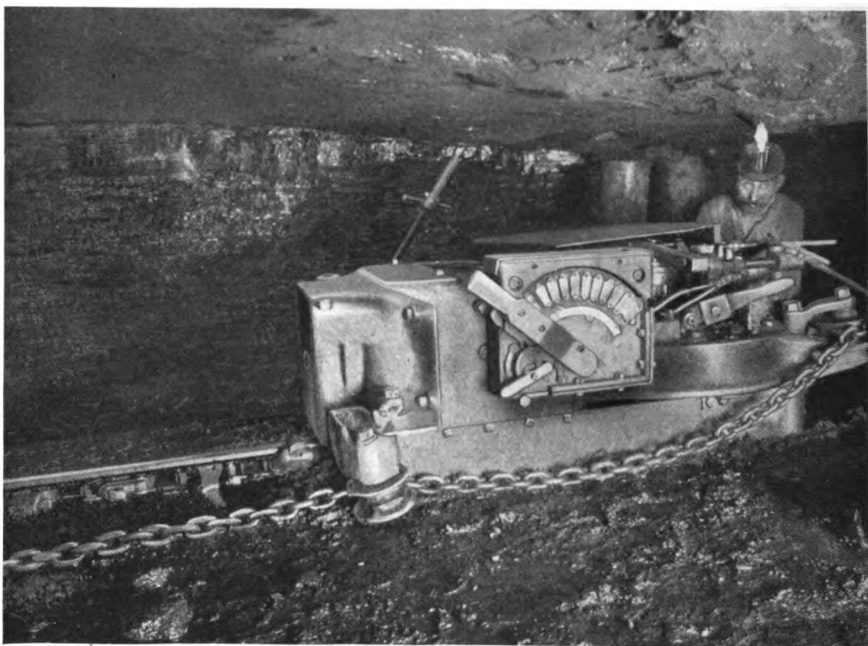
The photograph showing the machine

cutting across the face (page 566) was taken in one of the driest rooms in the territory; even so, trouble was experienced in keeping the flash powder dry enough to enable a good picture to be taken. In taking the picture of the machine just ready to sump under the face, page 566, the camera tripod had to be placed in about three inches of water. This place is about the wettest being worked at this time, and the dripping from the roof causes no little annoyance to the miners and makes the haulage roads hard to keep up.

Undercutting is usually done in the coal itself, as neither the gritty fire clay nor the sandstone bottom which sometimes replaces it, are suitable for cutting. A sulphur band near the bottom of the seam gives trouble in some mines, and makes it necessary to cut above the sulphur and lift the bottom coal after the rest of the seam is shot out. In other cases, the machines cut through the sulphur, as described on page 567.

#### USE OF MACHINES

In order to make coal mining a paying investment under such conditions, the



Sullivan Continuous Coal Cutter in the Beaver Mine. The top view shows the machine ready to sump at the rib; in the lower picture, the machine is cutting across the face. The coal is about  $3\frac{1}{2}$  feet high.

operator must employ the most economical means possible to win his coal. In early days, the coal was undercut by hand pick. Pick machines were introduced in 1898, but have not been extensively adopted. Eighty-five machines, including a few of the chain breast pattern, were used in 1904, when 23.09 per cent of the total product was mined by machine. By this time, hand pick cutting had practically disappeared, and the remaining 77 per cent was won by shooting from the solid, a dangerous practice, and a wasteful one on account of the high proportion of slack coal produced by the heavy powder charges necessary. In the year ending December 1, 1910, 561,688 tons out of a total of 1,473,874 were mined by machines, or 38.1 per cent.

#### CONTINUOUS CUTTERS

In the last two years, the situation has been changed materially by the introduction of electric chain machines of the Sullivan Continuous Cutter pattern. The chain breast type was less satisfactory than these, because the machine occupied so much room in front of the coal that props had to be moved and replaced to permit its passage, while the rear jack, forced into the roof at frequent intervals, constituted an added danger from falling top. The bulk and weight of breast machines and the severe labor connected with handling them in such low coal, also proved a serious handicap. The typical advantages of the continuous cutter are of great value in this field.

The Sullivan class "CE6" low vein machine is the pattern in principal use. More than 80 per cent of the chain machines now actually at work in this field are of this type and make. This machine stands only 21 inches high when cutting, and 30 inches high on its power truck. Props can be set less than six feet from the working face, and need not be moved while the machine is cutting. The cut made by these machines is a clean kerf  $4\frac{1}{2}$  inches high, and perfectly free, with-

out sprags at the back; while a square working face is left for the next cut. But little powder is needed for shooting, so that not only is the roof left unshaken, but very little coal is wasted in cutting. The proportion of lump coal is much higher than that obtained by any other method.

#### CUTTING A ROOM

The Sullivan Continuous Cutter is shown in operation in the pictures on pages 566 and 568, taken in the Beaver Mine. Page 566 (top) shows it at the rib, ready to run the cutter bar under the coal for the corner or sump cut. The machine in the lower picture was unloaded in the room neck, which in this case was at the left side of the room. A jack was set at the end of the right rib nearest the entry, and the machine pulled itself along the floor to this point on its feed chain. The rib and the face were then cut at one operation, with no other hand labor than that involved in setting the anchor jack and the take-up rig when the corner was reached; and in shoveling out the coarse cuttings from the cut behind the machine. In the picture the machine is part way across the face. The anchor jack is set to hold the feed chain and the machine with it, a little away from the face, to square it up, as it was being cut by machine for the first time. The mining is five feet three inches deep. This particular machine was equipped with feed gears which propelled it along the face on its chain at the rate of fifteen inches per minute. The room was mined in less than an hour, including sixty feet of undercut, unloading, handling and reloading the machine on its power truck, for transportation to the next working place, as shown in the cut on page 568.

#### MINING THROUGH SULPHUR

Practice regarding cutter bits varies in different mines. In the Sullivan machine, the bits are staggered in five positions or rows. In clean, hard coal, bits with pick points are used altogether. In



Sullivan Low-Vein Continuous Cutter on its self-propelling truck.

coal that is clean and soft, the most rapid progress is made with chisel-pointed bits. In both the Beaver and Bliss Mines, sulphur occurs near the bottom of the seam in sheets  $\frac{1}{8}$  to  $\frac{1}{4}$  of an inch thick. A combination of the two styles of bits is used here, the proportion of chisel points increasing when more impurities are met, in order to protect the cutter chain from the file-like cutting of the sulphur sheets.

These machines load themselves on their trucks, unload, and propel themselves in all operations on and off the truck, under their own power. This is a very important advantage in the low head room available, where lifting and moving heavy machines is handicapped by the cramped space in which the men must work.

#### THE BEAVER MINE

The Beaver Mine is operated under the same management as that of the Robert Gage Coal Company, and is one of the oldest openings in the district. Owing to natural difficulties, such as the sulphur referred to above, and the large amount of water encountered, as well as lack of capital, it has never passed the development stage. The present owners are attacking their problems in a systematic

and intelligent manner, and the methods they have adopted promise to overcome the difficulties and place the mine on a paying basis. At present, the Sullivan machines are used almost entirely in development, cutting entries and room necks and widening rooms. When enough working places have been squared up to provide cutting for all five Sullivan machines, the mine will become quite a factor in the production of the district.

The Robert Gage Coal Company and mines under the same management now employ about 20 Sullivan Continuous Coal Cutters.

The surface equipment of the Beaver Mine, (see page 564) is adequate to handle a large tonnage and is up-to-date in all respects. It includes a modern steel plate ventilating fan. The mine is equipped with a steam hoist and a steam driven electric generator for lights and power. A well-appointed machine shop and a forge shop enable equipment to be kept in constant repair. A company store is maintained for the convenience of the employees.

#### LABOR

The labor in the Michigan field is of a high class. The men are all union members. The basis of payment is \$1.01 per

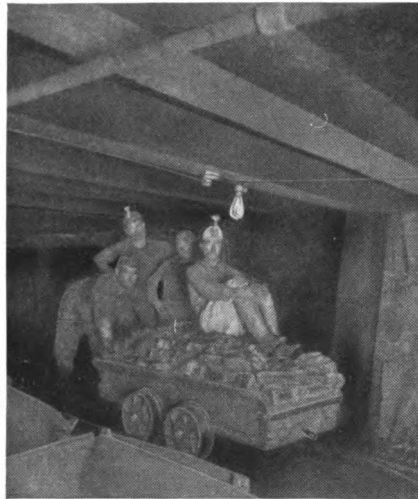
ton for all coal shot from the solid which will pass over a  $\frac{7}{8}$ -inch diamond bar screen. The slack which falls through the screen is not credited to the miner. When machines are used, the percentage of slack is smaller and the miner has little dead work to do. The wage scale in machine mines gives 59 cents per ton of screened coal to the loader, and 19 cents to the machine runner and his helper, or a total of 78 cents, which, deducted from the hand mining rate, leaves a margin or differential for the operator of 23 cents per ton. This is a substantial inducement for machine mining, aside from the greater value realized from the output. The men are paid off twice a month. Because of the proximity of the mines to towns and cities, the mining camp customary in other fields is generally lacking. The mine buildings stand in flat, rather desolate fields aloof from the other signs of civilization, and present a lonely view to the casual visitor. The men live in Bay City, St. Charles or Saginaw for the most part, where their families can enjoy schools and other advantages. They go to and from the mines each day by train. Most of the mines in this section run wash-rooms for the miners, where the men can leave their pit clothes to dry. An attendant keeps the building clean, sees to drying the clothes, and provides hot water, towels, soap, et cetera. For these conveniences a charge of four or five cents per day is made.

#### CONCLUSION

To summarize, the Michigan coal field comprises some 30 operating mines. Owing to competition from other fields, and to working handicaps which make

mining costs relatively high, it is improbable that the future will see Michigan coal in other than local markets, or that any very great increase in tonnage may be expected. Mining machines of the continuous cutting pattern, peculiarly suited to the conditions, have lately been introduced, and are proving exceedingly valuable, in reducing mining costs, increasing the price secured for the coal, and prolonging the life of the mines. This and other modern methods are giving coal mining in Michigan a fresh impetus, and should serve to hold control of the local trade, at least.

The writer is indebted to the mine officials of the Beaver Coal Company and of the Bliss Coal Company for photographs and for assistance rendered in preparing this article.



A car of coal at the Bliss Mine.

# Sullivan "Smooth Running" Hammer Drills

are easier to operate and less fatiguing to runners than other hammer drills. Jar and vibration in Sullivan drills is reduced to a low factor by a patented air cushioning device in the valve chamber.

This is one reason why runners can get more work out of Sullivan hammer drills in a day than from other similar tools, and why the cost of repairs is so low.

This "smooth running" element is most important in hand feed drills (which the runner must hold to the work by his own weight). Sullivan Hand Feed Hammer Drills are in a class by themselves for this reason alone.

Bulletin 266 C

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# MINE AND QUARRY


VOL. VI. No. 3

MARCH, 1912

Whole No. 21



STORM KING MOUNTAIN: DIAMOND DRILLS ON THE HUDSON



AIR COMPRESSOR ECONOMY  
THE STORM KING TUNNEL  
A LAKE SUPERIOR HOIST

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NEW YORK, N. Y.

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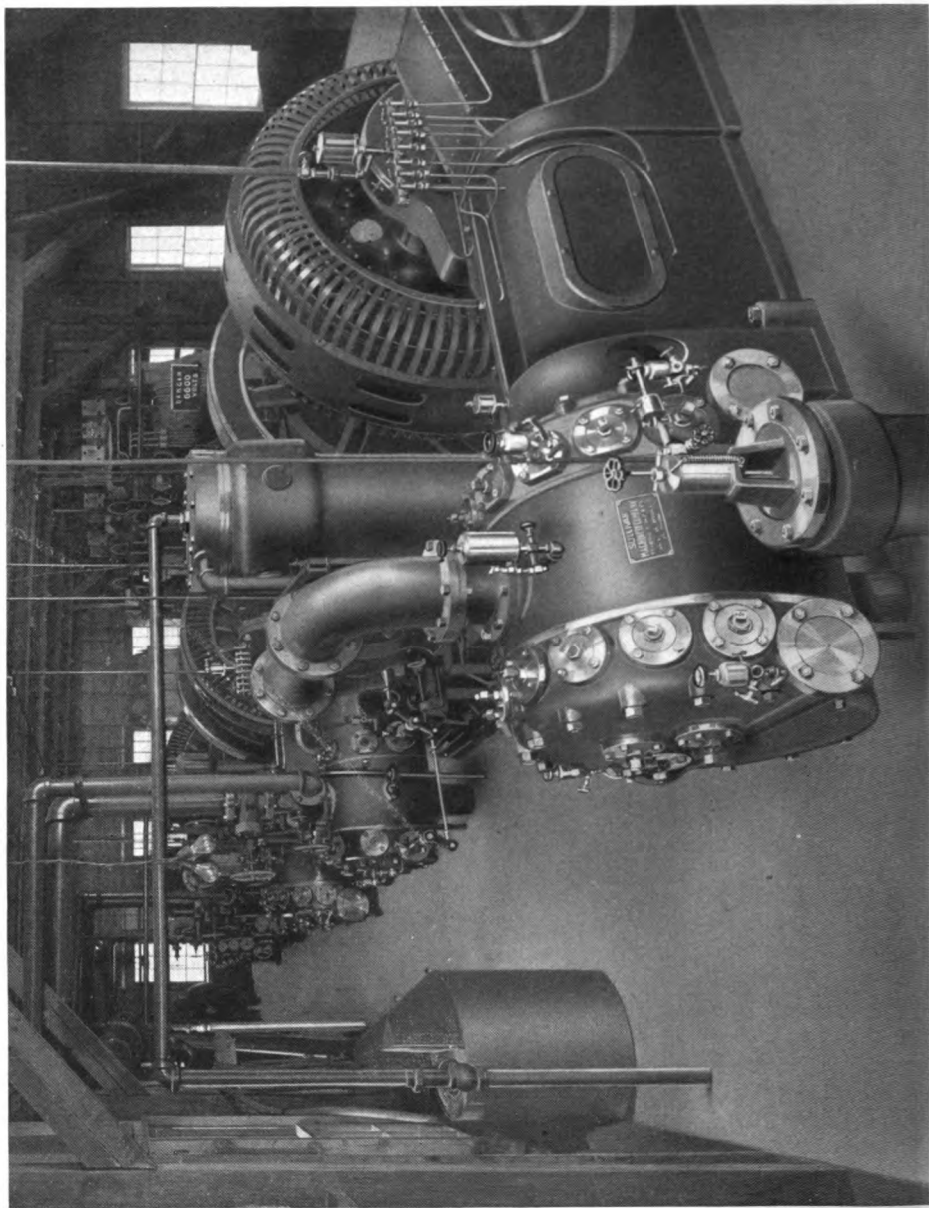
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QUARRY of any correction or change in address.

Efficiency-engineering, of which much has been heard in recent months, implies, from one point of view, an ability to accommodate one's vision so that a dollar looks as large across the room as it does at the end of one's nose. Applied to hoisting engines, for example, "Efficiency-engineering" may mean an investment in safety appliances, costing hundreds of dollars, which will prevent accident and consequent delay amounting to thousands; applied to air compressors or coal cutters, it means the selection of types in which power and maintenance charges will be least, per unit of work performed; applied to rock drills, the study of ground breaking costs and, for example, the substitution of drills, which can be handled by one man, for those requiring two. Two articles in this issue should make interesting reading for far-sighted engineers. One of them sets forth an example of economy in the operation of machinery, in concrete form. Other articles of this nature will appear in the issues now in preparation.

Our mailing list is growing all the time, and we are glad of it. But we cannot afford to send MINE AND QUARRY to anyone not interested, any more than such men can afford the time to read it. We are revising our address list now. If you want MINE AND QUARRY continued, please say so. If you want it stopped, please say so; card enclosed.

A reputation for honesty is the most valuable asset of any individual or any business firm. The honest manufacturer must be honest with himself first. The material he uses, the processes he employs, his inspection and testing of finished articles, his attitude toward small details and large questions of policy must all be marked by scrupulous honesty. And as he is honest with himself, so he must be honest with his customers. His engineers and his salesmen must not recommend or sell machines for work they cannot do or for which they are not adapted. They must make no guarantee which cannot be fulfilled if put to the test.

This standard of personal honesty must be maintained in the more impersonal relations of a business concern. Stretching the truth, creating an erroneous or misleading impression, over-stating or understating facts in such a way as to lead to wrong conclusions, are forms of dishonesty in advertising which can lead to only one result, the eventual, if slow, discrediting of that firm by the public whom it seeks to exploit—in spite of the statistics regarding the birth rate of the over-credulous. MINE AND QUARRY, and the company whose medium of expression it is, realize that so long as what they say and do is honest, so long as they treat their readers and their clients "on the square," just so long can they hope to be of service and to be successful. If you see in MINE AND QUARRY or in an advertisement of this company a statement which you cannot credit, it will be much appreciated if you draw our attention to the matter. Once discredited with you, the money put into advertising or into our business as a whole would better be dumped in Lake Michigan or some other handy body of water.



Power House of Smith, Hauser, Locher & Co., Central Park, New York, showing three Sullivan 2100-foot Compressors, direct connected to 200 H. P. 6,000 volt synchronous motors.

## AIR COMPRESSOR ECONOMY IN NEW YORK CITY

BY F. A. HALLECK<sup>1</sup>

Smith, Hauser, Locher & Co. are contractors for driving the Catskill aqueduct tunnel underneath New York City from 99th Street to 14th Street. The tunnel runs through solid rock for its entire length, about 225 feet below street level, and will be 14 feet in finished diameter, inside the concrete lining, down to 42nd Street; 13 feet to 23d Street and 12 feet to 14th Street. This section of the tunnel is known as contract 66, and has a total length of 4.38 miles.

Smith, Hauser, Locher & Co. were awarded the contract in May, 1911, and active work was begun immediately. Six shafts were sunk; three in Central Park at 93d St., 81st St., and 66th St. respectively; one at 50th St. and Sixth Ave.; one at 42nd St. in Bryant Park and one at 25th St. and Broadway. These shafts are now all down to tunnel grade, and two headings are being driven from each. Drilling is done at the three most northerly shafts with 36 Sullivan Rock Drills, Class UB-2, 3½ in., with differential valve motion, and Sullivan Hand Feed Hammer Drills, Class DB-19. A more complete description of this portion of the undertaking will appear in a later issue of this magazine.

## MOTOR-DRIVEN AIR COMPRESSORS

Compressed air for the three uptown shafts is supplied by a central plant in Central Park, opposite 81st St., consisting of three Sullivan "Class WN-2" direct connected, two stage air compressors, each driven by a self-starting synchronous motor, mounted on the crank shaft and rated at 400 H. P. at 188 R. P. M. The voltage is 6600 in the stationary armature and the revolving field is excited by a direct current generator running at 675 R. P. M., and delivering current at 125 volts. This generator is driven by a

belt from the crank shaft of the compressor. The compressors have high pressure cylinders 15½ inches in diameter, low pressure cylinders 26 inches in diameter, and a common stroke of 18 inches. This gives a piston displacement per unit, at 188 R. P. M., of 2,070 cubic feet per minute.

There are two Corliss inlet valves on each cylinder, moved by eccentrics on the crank shaft. The air is discharged through cushioned poppet valves of a special pattern. The port area of the discharge valves is 16 per cent of the cylinder area in the low pressure cylinder, and 17 per cent in the high pressure cylinder.

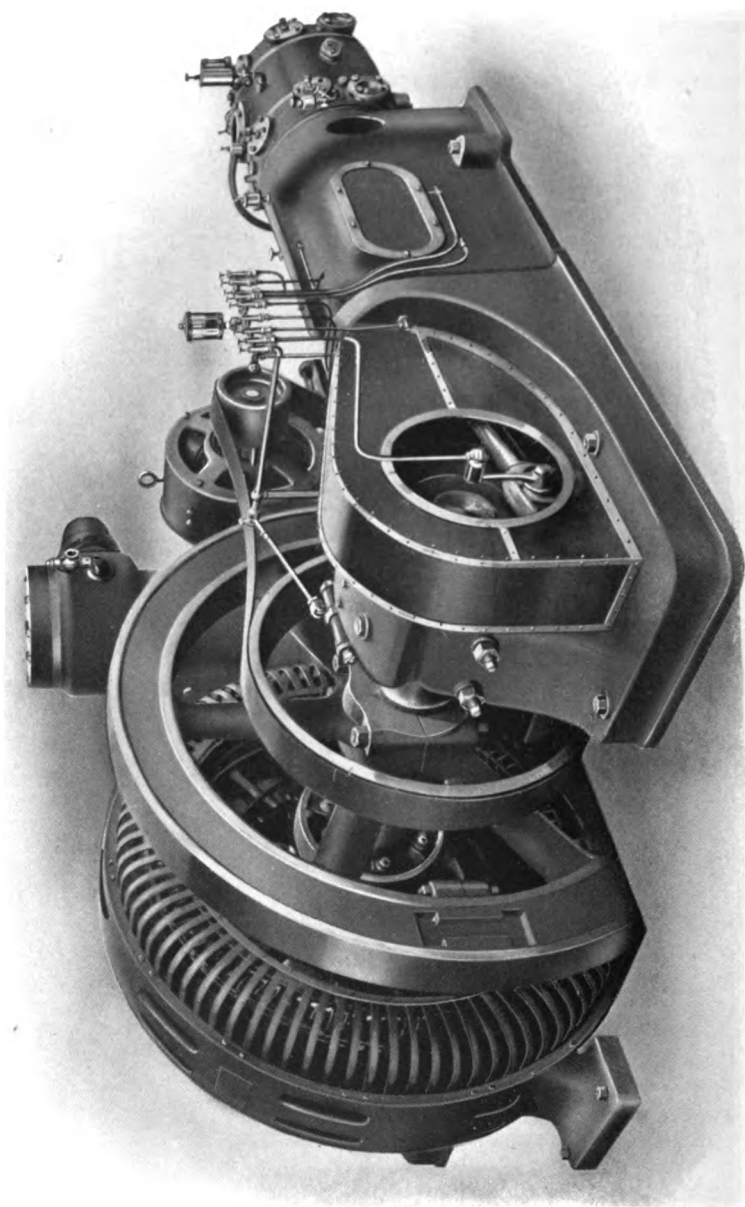
The intercooler in these machines is vertical and placed between the air cylinders. The photograph on page 576 shows the arrangement of the unit and its piping. The intercooler provides 10.75 square feet of cooling area per 100 cubic feet of free air. Copper water tubes are used.

The volume of air delivered is proportioned to the demand by means of a double beat unloading valve on the air inlet of the intake cylinder. This valve is either fully open or tightly closed, so that no choking effect is exerted on the entering air; and is operated by a variation of five pounds in the receiver pressure.

A fly-wheel weighing 7,000 pounds renders the action of the machine smooth and even in picking up its load, as well as at all other times, and eliminates peaks in the power consumption. The machine and fly-wheel without the motor weigh 22 tons.

At each of the three downtown shafts air is supplied by a single compressor of the two-stage, duplex pattern, of another make, direct-driven by a self-starting synchronous motor, using 6,600-volt current. The dimensions of these machines are: cylinder diameters, low pres-

<sup>1</sup>2624 W. Lake St., Chicago.



One of the three Sullivan 'WN2' Compressors, in plant of Smith, Hauser, Locher & Co., New York

sure,  $25\frac{1}{4}$  inches; high pressure,  $15\frac{1}{4}$  inches; stroke, 21 inches. The piston displacement of each unit is 2,119 cubic feet per minute at 188 R. P. M. Air enters the cylinder through piston inlet valves, and is discharged through poppet valves.

The amount of air delivered is proportioned to the demand by a clearance controller, designed to operate for no load, quarter, half and three-quarter loads. In this system of unloading, reservoirs are provided, into which a portion of the air compressed at each stroke is diverted, depending on the quantity of air required for use. This air flows back into the cylinder on the return stroke of the piston, decreasing, by the amount of its volume the intake capacity of the compressor.

#### TEST OF COMPRESSORS

The contractors decided to test one machine of each type, in order to learn as closely as possible the actual air delivery and power consumption, or in other words, the relative electrical input per cubic foot of air actually delivered. On January 18th, 1912, unit No. 3 of the Sullivan plant in Central Park was tested, and on January 22nd, the piston inlet machine at 50th St. was tested, under identical conditions.

At the time these tests were made, both

compressors had been at work under actual service conditions for a number of weeks. No special preparations or adjustments for the test were made on either machine. The makers of each compressor were given abundant notice of the time and purposes of the test, and both had engineers on the ground, who checked the readings and inspected the machines and apparatus.

The results sought were three:

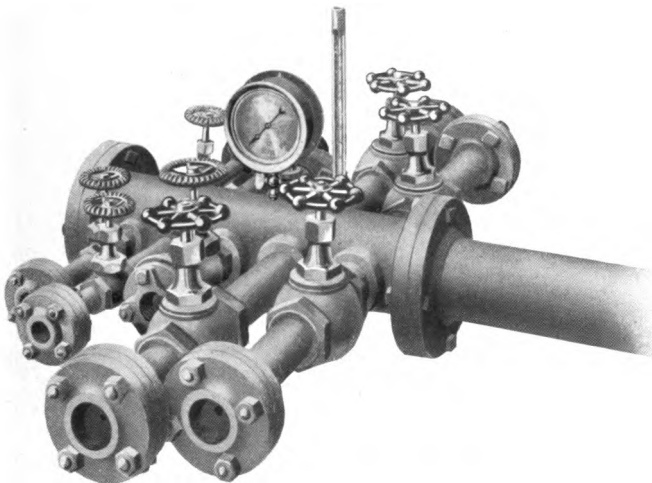
1. Delivery efficiency.
2. Power consumption.
3. Amount of cooling water used.

#### DELIVERY EFFICIENCY

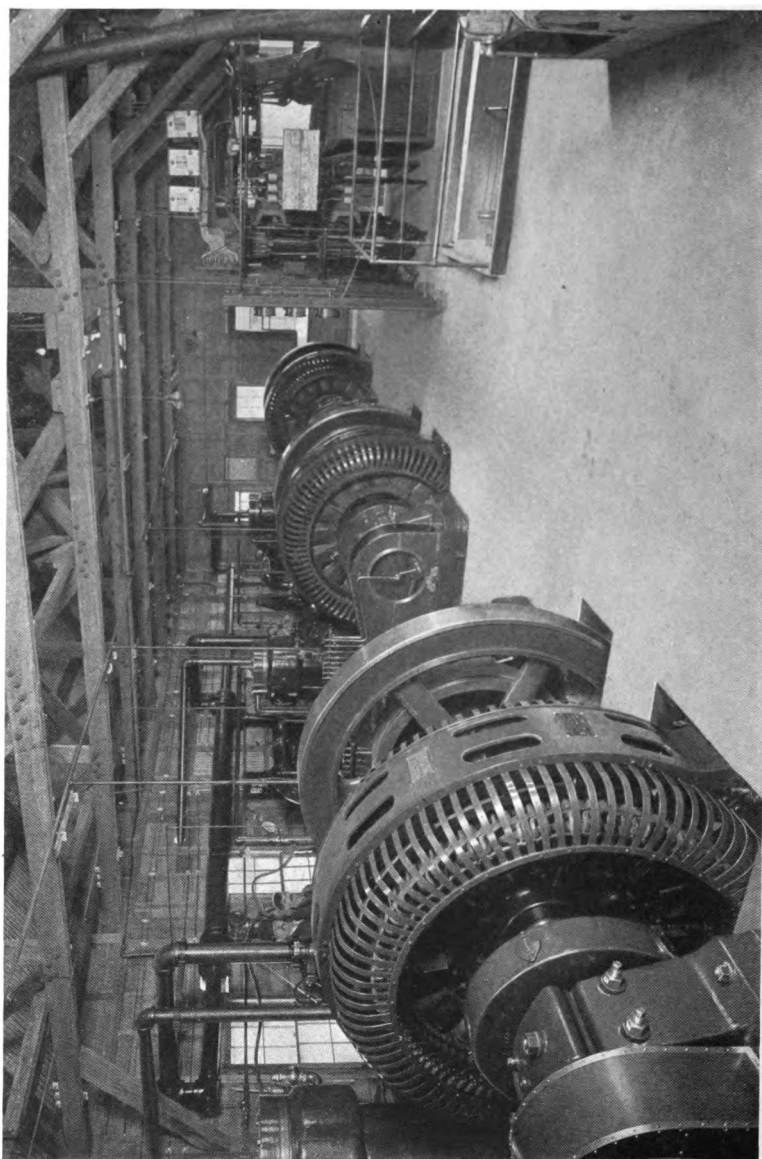
Indicator diagrams on the low pressure air cylinders showed a volumetric efficiency of 96 per cent for the Sullivan machine and of 95 per cent for the piston inlet unit. This method, however, should properly be called "intake efficiency," since it makes no allowance for leakage past the piston or slippage at the discharge valves.

The air actually discharged by each compressor at a given pressure was therefore measured by orifices and the actual volume computed by the use of Fliegner's formula.

The same apparatus was used in the



Manifold and Battery of Orifices for testing delivery efficiency



Sullivan "WN2" Compressors in Central Park Plant of Smith, Hauser, Locher & Co.

two tests. All gauges were tested and adjusted by a Crosby weight gauge tester, and the thermometers were tested by immersion in snow and water.

#### THE "ORIFICE" TEST

The quantity of air delivered was measured by a battery of orifices (shown in the photograph on page 574) connected to the main air line. These orifices were eight in number, ranging in diameter from  $\frac{1}{32}$  up to  $\frac{5}{8}$ -inch, and were made in plates,  $\frac{1}{2}$ -inch thick, connected to a manifold by ordinary globe valves. The orifices were countersunk with a  $\frac{1}{16}$ -inch radius next the globe valves, so that the escaping air completely filled the orifices. The manifold was equipped with a thermometer well and tapped for a pressure gauge. In running the test, orifices were opened until the pressure was exactly maintained at a predetermined point. The maximum flow of air at the full pressure showed the delivery efficiency of the compressor.

The type of orifice used had been tested carefully, by the displacement tank method, and the quantity of air discharged agreed accurately with Fliegner's formula.

At 188 R. P. M., the Sullivan compressor filled two  $\frac{5}{8}$ -in. orifices, two  $\frac{1}{2}$ -inch, and one  $\frac{1}{8}$ -inch. The piston inlet machine, at the same speed, filled two  $\frac{5}{8}$ -inch orifices and two orifices  $\frac{1}{2}$ -inch in diameter.

This gives an actual delivery capacity of 1814 cu. ft. of free air for the Sullivan machine, or a delivery efficiency of 87.7 per cent; and a delivery capacity of 1676 cu. ft., or 79.1 per cent delivery efficiency for the piston inlet compressor.

Readings on the latter machine were also taken at  $\frac{3}{4}$ , and  $\frac{1}{2}$  and  $\frac{1}{4}$  load. The orifice test showed deliveries, respectively, of 1153, 607 and 248 cu. ft. of free air per minute, or ratios of delivery to piston displacement as follows:  $\frac{3}{4}$  load, 54 per cent;  $\frac{1}{2}$  load, 29 per cent;  $\frac{1}{4}$  load, 12 per cent.

#### DERIVATION OF DELIVERY RATIOS FOR SULLIVAN COMPRESSOR

As the unloading device on the Sullivan compressor was of the total closure pattern, the following figures are derived from full load and no load readings.

	Ft. Air	Ratio of delivery to Pis. Disp.
Compressor running at full load $\frac{3}{4}$ time, $\frac{1}{4}$ time no load.....	1362	67%
Compressor running at full load $\frac{1}{2}$ time, $\frac{1}{2}$ time no load.....	907	44%
Compressor running at full load $\frac{1}{4}$ time, $\frac{3}{4}$ time no load.....	453	22%

During the full-load test of the Sullivan compressor, six readings were taken, at intervals of three minutes. Three readings were taken with the machine unloaded.

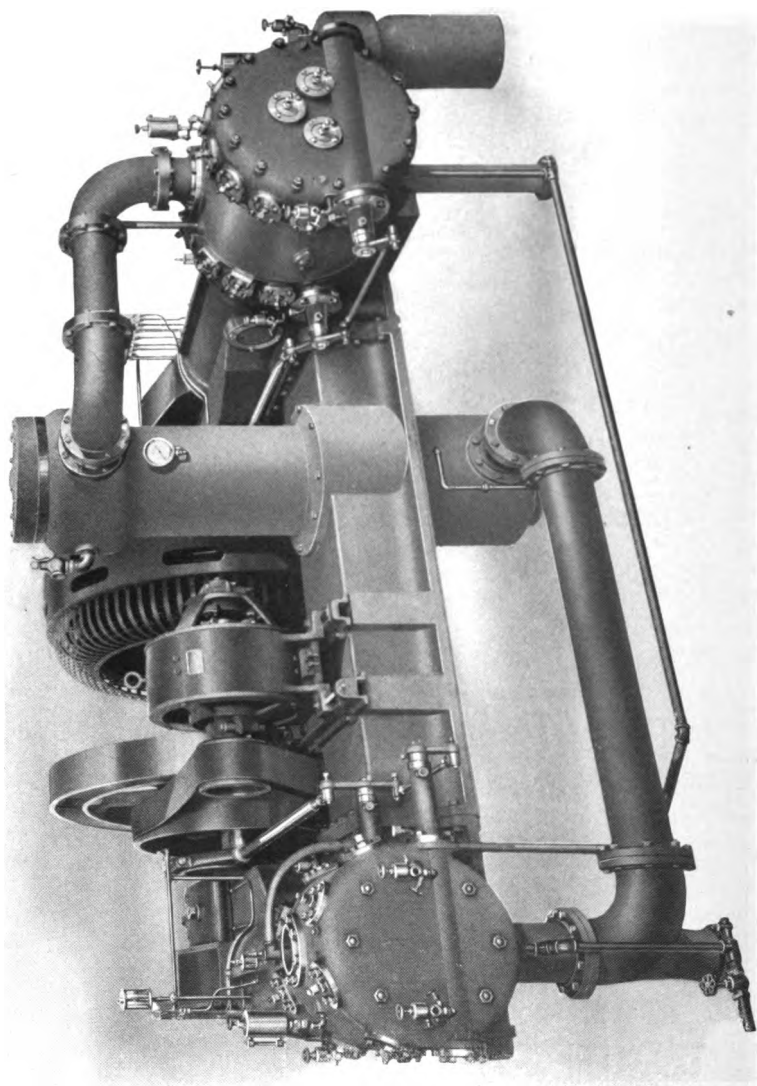
The piston inlet compressor was observed at five-minute intervals. Four readings were taken at full load, two at  $\frac{3}{4}$  load, three at  $\frac{1}{2}$ , three at  $\frac{1}{4}$  and two at no load. These observations are shown in detail for both machines on page 577, and on page 578 is the calculation for delivery efficiency, based on the orifice test readings from the Sullivan compressor. The volumes compressed by the piston inlet machine were, of course, computed in the same way.

#### COOLING WATER

The temperature of the cooling water passing through the intercooler and cylinder jackets was taken at various points, as shown on page 577 and it was carefully weighed. On the Sullivan machine the intercooler circulation was 54 pounds per minute, and that through the cylinder jackets, 22 pounds, or a total of 76 pounds. The Sullivan machine therefore used  $\frac{1}{2}$  gallon per 100 cu. ft. of free air, as compared with one gallon (see table) for the piston inlet compressor.

#### POWER CONSUMPTION

The figures on page 578, taken from the Sullivan compressor test, show how the



Rear view of one of the direct-connected Sullivan Compressors, showing details of construction

## LOG OF TEST OF SULLIVAN AIR COMPRESSOR

Size, 26" - 15½" × 18" 188 R.P.M.

New York City, Jan. 18, 1912

Full Load.

Barometer 30.1 in.

Pressures.				Temperatures.								Power.	
Time.	Intercooler	Terminal	Orifice	Air Intake	Air Entering Intercooler	Air Leaving Intercooler	Air Discharge	Orifice	Cooling Water Inlet	Cooling Water Discharge	Kilo-Watts.	Horse-power.	
2:09	32	97½	97	41	275	124	260	250	37	114	313.3	420	
2:12	32	98	97	41	275	124	260	251	37	114	314.4	422	
2:15	32	98	97	41	275	124	260	251	37	114	315.2	423	
2:18	32	98	97	41	275	124	260	251	37	114	315.2	423	
2:21	32	98	97	41	275	124	260	251	37	114	315.2	423	
2:24	32	98	97	40	275	124	260	262	37	114	315.8	423.5	
Average	32	98	97	41	275	124	260	251	37	114	314.8	422.4	
No Load.													
4:46		88	87	40				109			32.4	43.5	
4:49		88	87	40				109			32.4	43.5	
4:52		88	87	40				109			32.4	43.5	
Average		88	87	40				109			32.4	43.5	

Orifices open. - ⅝ - ⅝ - ⅝ - ⅝ - ⅝ - ⅝.

Orifice open. ⅜.

LOG OF TEST OF PISTON-INLET COMPRESSOR AT NEW YORK CITY  
Size, 25¼" - 15¼" × 21" 188 R.P.M. Displacement 2119 cu. ft. per min.

Inlet Sleeve—9⅝" dia. Piston rod 2¼" dia.

Full Load.—Orifices open, ⅝", ⅝", ⅝", ⅝".

Jan. 22, 1912. Barometer 30.1 in.

Pressures.				Temperatures.					Power.				Cooling Water Permits No Air.		Cu. Ft. Air per min. Free from Oil.	Horse Power per cu. ft. Air.
Time	Inlet Cooler	Terminal	Orifice	Air Intake	Air Entering Intercooler	Air Leaving Intercooler	Air Discharge	Orifice	Cooling Water Inlet	Cooling Water Discharge	Kilo-Watts.	Horse-power.	Permits No Air.	Permits No Air.		
2:10	28	98	96½	44	249	84½	270	257	37	80	299	401	152	1	1676	23.9
2:15	28	98	96½	44	250	84½	270	258	37	80	298	399				
2:20	28	98	96	44	250	84½	270	260	37	80	300	402				
2:25	28	98	96	44	250	85	270	260	37	80	300	402				
¾ Load—Orifices open. ⅝ - ⅝ - ⅝ - ⅝.																
2:55		98	80	44				225			227	304			1152	26.4
3:00		98	80	44				232			227	304.				
½ Load—Orifices open. ⅝ - ⅝.																
3:15		98	49	44				212			165	221			607	56.2
3:20		98	49	42				210			163	218.3				
3:25		98	49	42				208								
¼ Load—Orifice open. ⅝.																
3:40		98	36	42				186			99.5	133.5			248	53.6
3:45		98	36½	42				181			99.5	133.5				
3:48		98	36½	42				176			98.5	132				
No Load—Orifice open. ⅜.																
4:00		62	61	42				140			43.7	58.6			8.5	
4:03		62	61	42				140			43	57.7				

## Delivery Efficiency

Full Load	No Load
1.083	.0069
14.8+97=111.8	14.8+87=101.8
460+251=711	460+109=569

Fliegner's Formula:  $G = 53A \sqrt{\frac{P}{T}}$

G = Pounds of air per second.

A = Area of orifices in square inches.

P = Absolute pressure in lbs. per sq.

T = Absolute Temperature Fahr. at

orifices.

Barometer 30.1 in. Atmospheric Pressure =  $4908 \times 30.1 = 14.77$  lbs. per sq. in.

Area of Orifices:

$\frac{5}{8}$ -in. = 3068

$\frac{3}{4}$ -in. = 3068

$\frac{1}{2}$ -in. = 19635

$\frac{3}{8}$ -in. = 19635

$\frac{1}{4}$ -in. = 9767

1.0830 sq. ins.

$$G = \frac{53 \times 1.083 \times 111.8}{26.66} = 2.407 \text{ lbs. per sec.}$$

Wt. of 1 cu. ft. air at Intake Temp. =

$$W = \frac{1.325 \times B}{460 + T} = \frac{1.325 \times 30.1}{501} = .0796 \text{ lbs.}$$

$$\frac{2.407}{.0796} \times 60 = 1814.4 \text{ cu. ft. per min.}$$

Displacement of 26-in. X 18-in. cylinder at 188 R. P. M. with piston rod  $2\frac{1}{2}$ -in. dia.

$$\text{Area 26-in. cyl.} = 530.94$$

2

$$\text{Area } 2\frac{1}{2}\text{-ins. rod} = \frac{1061.88}{4.91}$$

$$1056.97 \text{ sq. ins.}$$

$$\frac{1056.97}{144} \times 1.5 \times 188 = 2070 \text{ cu. ft. per min.}$$

Delivery efficiency =  $\frac{1814.4}{2070} = 87.65\%$ .

$$\text{Volume at No Load} = \frac{53 \times .0069 \times 101.8}{\sqrt{569}} = .0156 \text{ lbs. per sec.}$$

$$\frac{.0156}{.0797} \times 60 = 11.7 \text{ cu. ft. per min.}$$

## Power Efficiency

1814.4 cu. ft. air.	422.4 H. P.	314.8 K. W.
422.4 = 2328 H. P. per cu. ft. = 23.28 H. P. per 100 cu. ft. air.		
1814.4		
314.8 = 1735 K. W. per cu. ft. = 17.35 K. W. per 100 cu. ft. air.		
1814.4		
1814.4 X 60 = 108864 cu. ft. air per hour.		
108864		
314.8 = 345 cu. ft. air per K. W. hour.		
Horse power at no load = 43.5 = 32.4 K. W.		

Horse power at no load = 43.5 = 32.4 K. W.

Indicated Horse power:

L.P. = 100 + 103 = 203

M.P. = 75 + 74 = 147

Full Load Total = 350 HP

No Load Total = 18 HP

23 lbs. M.E.P.

23 X 26 X 188 X 1.5 = 103 HP

350 HP

1 HP. 2 1/2 in. M.E.P.

Head End

Crank End

48 lbs. M.E.P.

48 X 18 X 188 X 1.5 = 75 HP

350 HP

5 lbs. M.E.P. = 8 HP

5 lbs. M.E.P.

47 lbs. M.E.P.

47 X 18 X 188 X 1.5 = 74 HP

350 HP

8 HP. 5 lbs. M.E.P.

No Load = 1 HP = 18

Factor = 6

Friction = 15

43.5 X .89 Motor Eff. = 39 HP

# RESULTS OF COMPETITIVE AIR COMPRESSOR TESTS AT NEW YORK CITY

Jan. 18, 1912—Sullivan, 26" — 15½" × 18" 188 R.P.M., D.C. to 400  
HP. Westinghouse Syn. Motor.

Jan. 22, 1912—Piston-Inlet 25¼" — 15¼" × 21" 188 R.P.M., D.C. to  
360 HP. Crocker-Wheeler Syn. Motor.

Full Load														
	Baromet Press	Actual Air Delivered Cubic Feet	Deliv'd Eff. Comp	Temper Air Pressure	Horse Power	HP Per 100 Cu Feet	Intercool Pressure	Air Inlet Temp	Air Discharge Temp	Inlet Temp	Disch Temp	Cooling Water Temp	Lbs Per Min	Gallons Per 100 Cu Feet
Sullivan	2070	1814	87.7%	98	422	23.28	32	41	260	37	114	76	½	
Pist.-Inl.	2119	1676	79.1%	98	402	23.9	28	44	270	37	80	152	1	
¾ Load														
Sullivan		1362		98	328	24								
Pist.-Inl.		1153		98	304	26.4								
½ Load														
Sullivan		907		98	233	25.7								
Pist.-Inl.		607		98	220	36.2								
¼ Load														
Sullivan		453		98	138	30.5								
Pist.-Inl.		248		98	133	53.6								
No Load														
Sullivan		11.7		98	44									
Pist.-Inl.		6.5		98	58									

NOTE.—Partial Load figures for Piston-Inlet machine taken directly from tests with clearance controller. Sullivan partial loads figured from full load and no load tests.

power efficiency ratings were arrived at. The table on this page summarizes the results of the two tests, in convenient form for comparison. The Sullivan power consumption at partial loads was computed in the same way as the air delivery. For example, for ¾ load, the compressor was assumed to operate at full load for three-fourths of a specified time, and the remainder of the time at no load. The table on page 580 shows the power consumption necessary to compress 2,000 feet of free air per minute, to 100 pounds pressure, per hour of operation, and indicates graphically the method of rating the Sullivan compressor at partial loads. The power consumed will be the same,

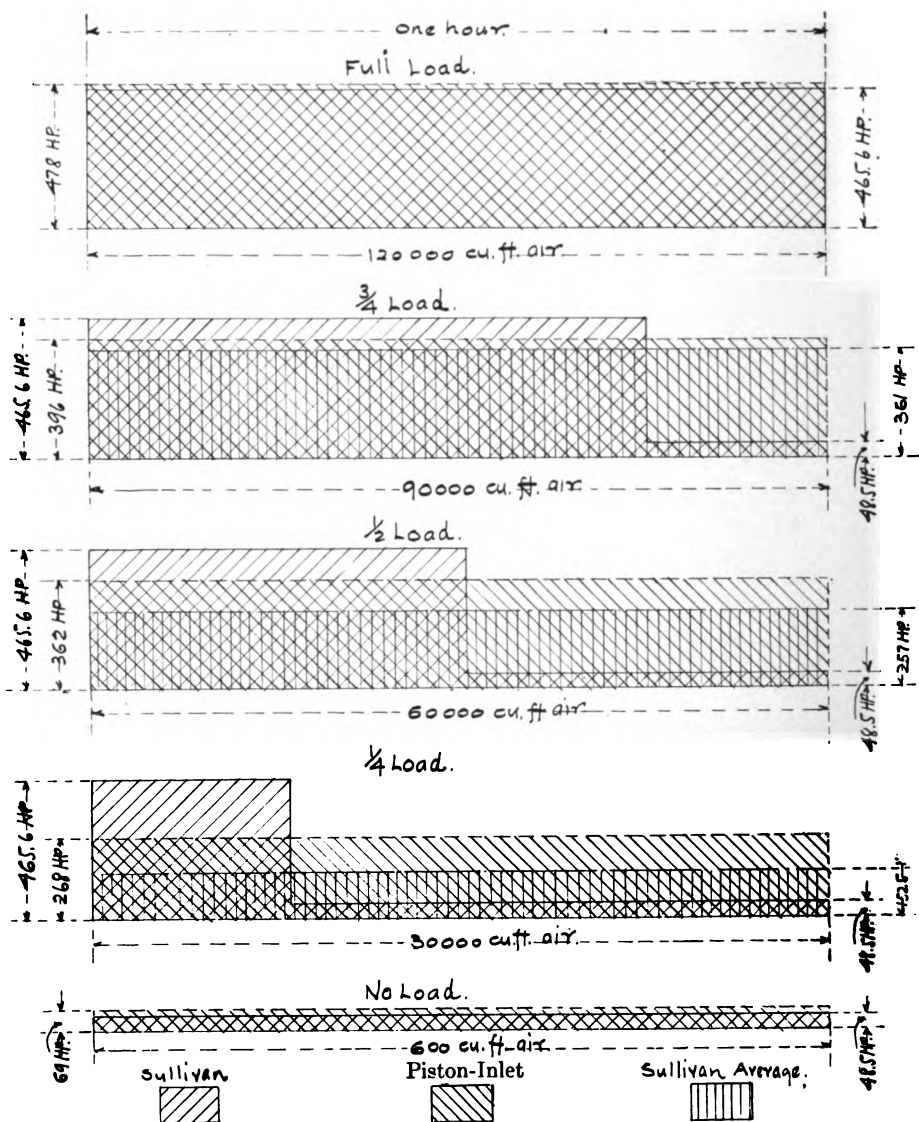
whether the machine is unloaded once or a dozen or more times in a given period.

The curve on page 581 shows the relative power consumption of the two types of compressor in a very effective way, and on page 582 are other curves, figured to show the relative cost of compressing air with each compressor at varying load factors, at the price actually charged for power in New York City.

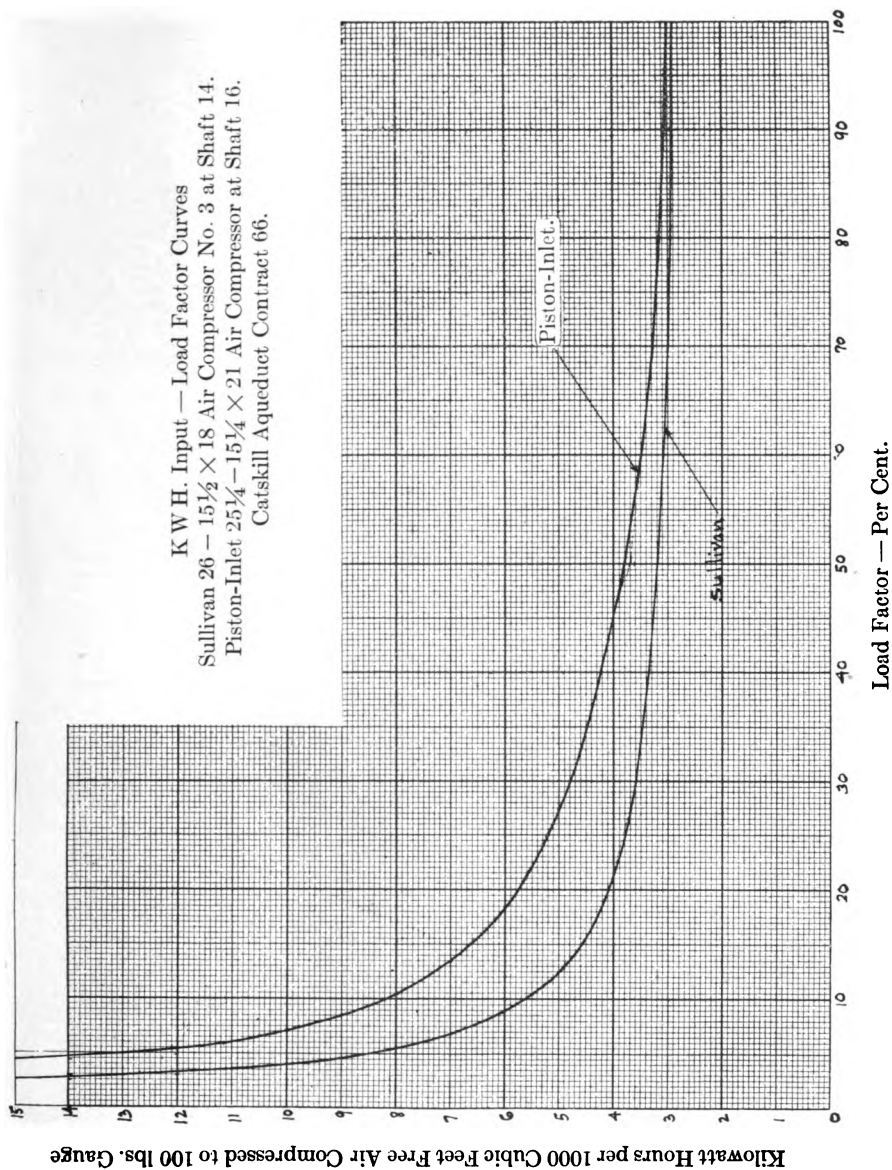
For the reader's convenience, the table below shows the cost of supplying the same volume of air by each outfit of three compressors for one year of 300 days, at full load, three quarter, half and one-quarter loads:

## POWER DIAGRAM.

Comparison of Power used by Sullivan and Piston-Inlet 2000 cubic feet.  
Direct Connected Motor Driven Air Compressors at various loads.  
Based on tests made at New York City, Jan. 18 & 22, 1912.

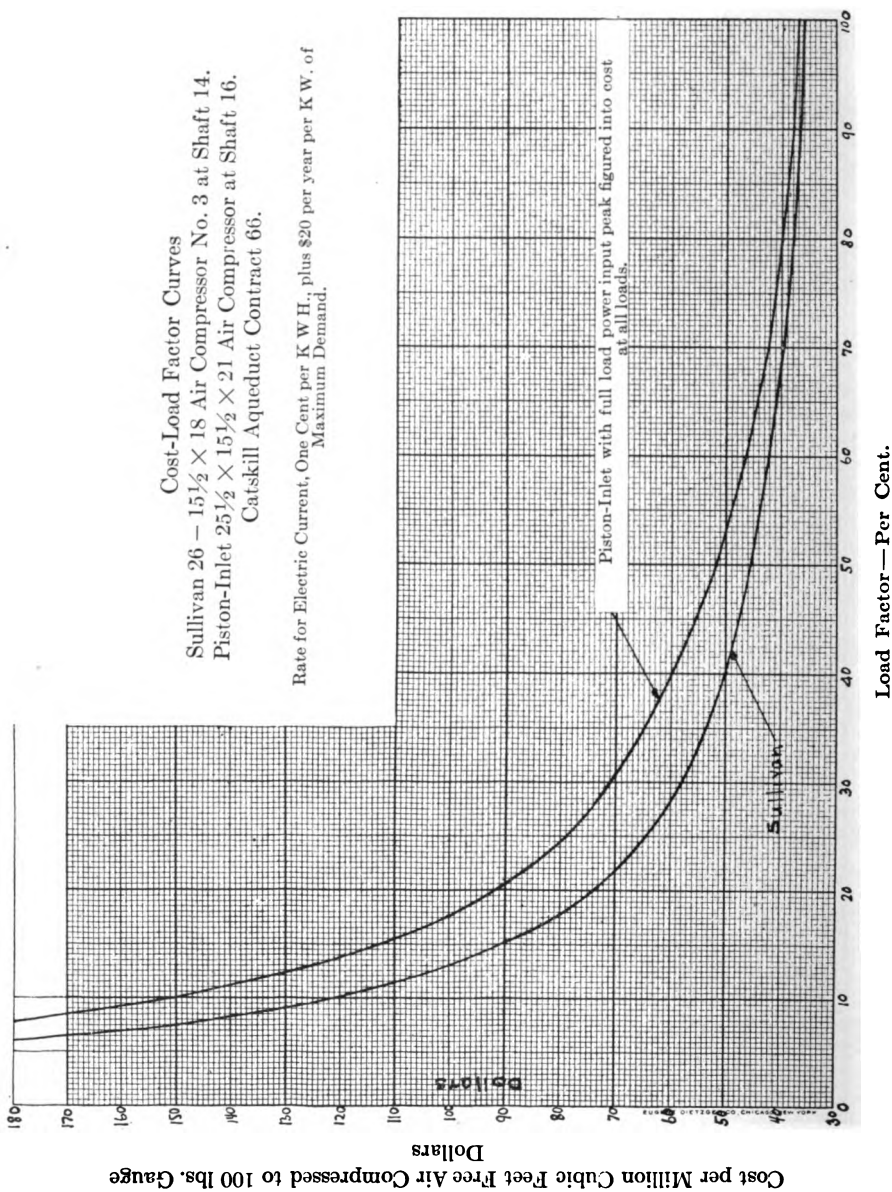


KW H. Input — Load Factor Curves  
 Sullivan 26 —  $15\frac{1}{2} \times 18$  Air Compressor No. 3 at Shaft 14.  
 Piston-Inlet 25  $\frac{1}{4} - 15\frac{1}{4} \times 21$  Air Compressor at Shaft 16.  
 Catskill Aqueduct Contract 66.



Cost-Load Factor Curves  
 Sullivan 26 -  $15\frac{1}{2} \times 18$  Air Compressor No. 3 at Shaft 14.  
 Piston-Inlet  $25\frac{1}{2} \times 15\frac{1}{2} \times 21$  Air Compressor at Shaft 16.  
 Catskill Aqueduct Contract 66.

Rate for Electric Current, One Cent per K W H., plus \$20 per year per K W. of Maximum Demand.



	$\frac{1}{4}$ Load.	$\frac{1}{2}$ Load.	$\frac{3}{4}$ Load.	Full.
Cu. ft. free air per year of 300 days.....	58,773,600	1,175,472,000	1,763,208,000	2,350,940,000
Cost per 1,000,000 cu. ft., Sullivan Compressor.....	\$64.00	\$45.00	\$39.00	\$36.00
Cost per 1,000,000 cu. ft., Piston-Inlet Compressor.....	79.00	52.00	41.00	37.00
Saving per 1,000,000 cu. ft. in favor of Sullivan.....	15.00	7.00	2.00	1.00
Saving per annum, Sullivan over Piston-Inlet Com- sor.....	\$8,815.04	8,228.30	3,526.42	2,350.94

As it is estimated that the load factor of this plant under ordinary working conditions will be about 60 per cent, the

actual saving of the Sullivan compressor plant in power cost will amount to \$5,600.00 per year.

### CHANNELING "PRESSURE" STONE

Operators of stone channeling machines occasionally encounter difficulty in putting down cuts, owing to side pressure or creeping of the rock.

This usually occurs in limestones or sandstones which have been heaved up or through some other disturbance have settled and placed the layers under a lateral strain. An interesting example of this occurs in the sandstone beds in northern Ohio, at Amherst and vicinity. The usual method of opening a quarry in this field is by cutting two parallel channels about six feet apart and removing the key blocks across the end of the quarry. This affords room for the expansion which takes place, and which amounts sometimes to four or five inches. A photograph of one of these large sandstone pits is shown on the next page.

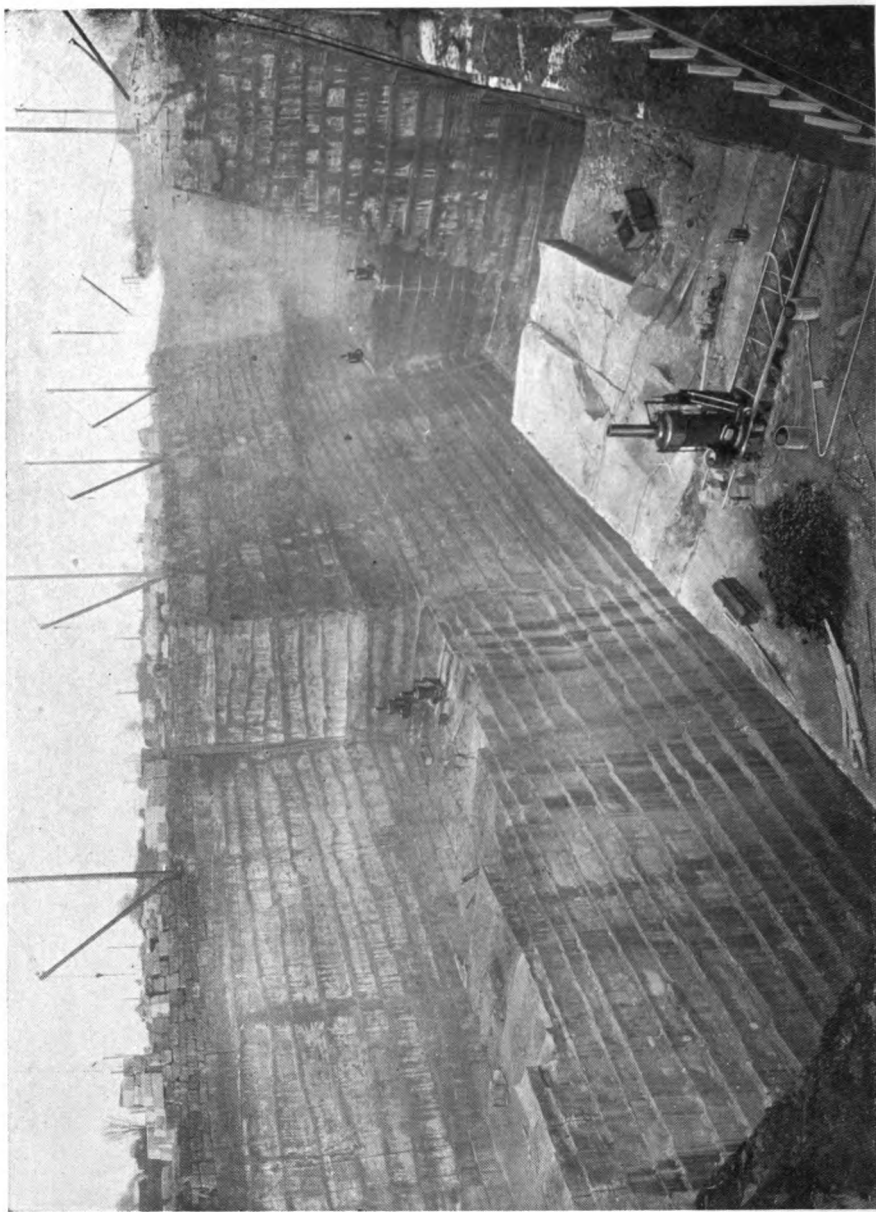
Difficulty from side pressure was encountered by the contractors for the new canal and lock at Sault Ste. Marie, Mich., where the Potsdam sandstone is very hard and in layers of irregular thickness and pitch. On the New York Barge Canal, the Niagara limestone, near the west end of the undertaking, has also given trouble from this source. After a cut has reached a depth of six feet, pressure begins to act and closes up the cut entirely.

Evidence of the pressure is found in

the fact that the rock is badly broken and splintered. To avoid trouble from this source, the contractors have adopted the plan of blasting out a center cut through the length of their section, some 25 to 30 feet in width, before starting to channel. As the canal is 94 feet in width, this leaves a 32-foot bench on each side, and the danger of shattering the permanent side walls, to avoid which channelers are employed, is very small. This center cut relieves the side pressure, so that when the channel cuts are put in, the channel does not close up.



A Sullivan "Z" Channeler on the Barge Canal, Lockport, N. Y.



Buckeye Quarry of the Ohio Quarries Company, Amherst, Ohio. This company employs 16 Sullivan Channelers

### A SMALL AIR LIFT PLANT, AT MERIDIAN, IDAHO

Editor's Note; condensed from an article by EDMUND F. BLAKE, C. E., Boise, Idaho, in "Engineering and Contracting," September, 1911

The village of Meridian, Idaho, with a population of about one thousand, is located in the Boise Valley, about nine miles west from the city of Boise, on the Oregon Short Line Railroad. It is also on the line of the Boise Valley Interurban Railway, and is the center of a rich fruit, grain, and hay district.

It was known that good supplies of soft non-mineralized water were obtainable at a depth of from 200 to 300 feet, and as no gravity or river supply was available, a deep well was decided upon. An eight-inch well was driven to a depth of about 212 feet and six-inch tubing forced down to the 252-foot level, where the flow of water was encountered in a deep stratum of coarse gravel underlying a four-foot stratum of very tough clay. The water rose in this well to a point about 60 feet below the surface, giving a depth of water of 192 feet. This level has been practically maintained to the present time.

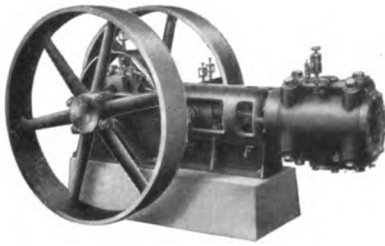
It was decided to pump this water by compressed air into a receiving basin, and then by means of a centrifugal pump into elevated tanks. The small size of the tubing, six inches, was one of the factors against installing a deep well pump. An old air compressor, operated by gasoline engine, was secured to test and clean the well, and the result of this preliminary work indicated that the supply was practically inexhaustible and that it was entirely feasible to lift the water from the well by compressed air as planned.

The permanent pumping plant consists of one 10 x 12-inch, class WG-3 Sullivan air compressor, operated by a belt from a 50-horsepower, three-phase, sixty-cycle, 220-volt, alternating current motor, with starting compensator. This motor is also direct connected to the centrifugal pump which supplies the elevated tank,

by means of a friction clutch coupling. The air compressor runs at 165 revolutions per minute, and is fitted with a 3½-inch automatic unloading valve for throwing off the load when the receiving basin is full. The compressor discharges into a 36-inch by six-foot air receiver, to prevent pulsations in the pipe line.

The compressor is practically automatic in its action. The main working parts are entirely housed in with an iron casing and the crank shaft, crosshead, etc., are oiled by the splash system of lubrication. The air inlet and discharge valves are of the automatic poppet type, located at the ends of the cylinder and acting in a radial direction to the axis of the cylinder bore; so that the entrance and discharge ports are very short and direct and there is little loss from clearance.

Under ordinary conditions, this compressor delivers air to the well at about 40 pounds per square inch. The air is sent down 170 feet into the well in an air pipe 1½ inches in diameter, which is suspended in the six-inch tubing and is fitted with a reverse elbow at the bottom, so that when released, the air acts directly in lifting the volume of water. The well is provided with a six-inch outlet into the receiving basin and one six-inch discharge for waste water to an outside pit. Each outlet is fitted with controlling gates. In July of last year, careful tests were made to determine the capacity of various parts of the pumping plant, and to determine what the 24-hour domestic consumption of the village was. The maximum capacity of the well was found to be about 225 gallons per minute, with air at 38 pounds pressure. The time required to fill the basin to the point where the centrifugal pump is thrown automatically into action, was found to be about thirty-four minutes. The receiving basin has a capacity of



Sullivan Single Stage Belted Air Compressor

about 8,000 gallons and the pump starts when the basin contains 7,500 gallons. It was found to require about eighteen

minutes to empty the basin when full, with the air compressor discharging to the well at the same time.

By throttling the gate on the force main, the capacity of the pump may be reduced, so that in case of fire a supply of about 200 gallons per minute can be kept up indefinitely. In early June, about 64,000 gallons of water was required every 24 hours to supply the demand. The elevated tank has a capacity of 60,000 gallons and is 110 feet high from the top of the foundation to the water surface in the tower.

### A CARBONIFEROUS CORNER OF CHILE

By Otto A. Schmidt, M. E.<sup>1</sup>

The district which the writer proposes to treat of in this paper comprises the southern part of the coal field which is situated on the coast of Chile, between the port of Talcahuano, near Concepcion, on the north and, as far as has yet been discovered, a point about four miles south of the port of Lebu, an extent of about 70 miles. Inland, eastwards, it stretches with various breaks, caused by the upheaval and subsequent denudation of the strata, to the mining village of Curanilahue (a distance of about fifty miles), where the Arauco Company, Ltd., an English firm, has conducted mining operations for several years.

In the Lebu district, which is the one dealt with in this paper, mining has been carried on since the early seventies, the sphere of operations extending for a radius of three miles on both banks of the Lebu river. With the exception, however, of the pits of the Compañía Nacional Carbonífera on the north side, and those of the Compañía Victoria and the Minas Errazuriz on the south, very little has been done in the way of extensive mining, owing, no doubt, to the imperfect knowledge which the earlier workers had of the faults that traverse the region.

<sup>1</sup>Santiago, Chile.

#### MODERN CRETACEOUS FORMATION

The formation in which the coal is found is considered to be tertiary. Señor Ignacio Domeyko (late Professor of Mineralogy in the University of Chile, and author of a very comprehensive work upon the minerals found in Chile) thinks it belongs to the more modern of the cretaceous series. Neither terrestrial nor marine fossils appear to be very abundant, but those that have been found indicate that this conclusion is the right one.

At the Errazuriz Mine, on the south side of the river, eight seams are found, four of them being workable, while at the neighboring mine of the Compañía Victoria, but separated from the former by a fault of two hundred meters throw, only two of the seams have as yet proved to be of sufficient thickness to be worked. This fault was located by bore holes with a Sullivan "B" Diamond Prospecting Core Drill in charge of the writer. Five holes were bored, with an average depth of 352 feet. The accompanying photograph shows the Sullivan Diamond Drill at work at the Errazuriz Mine.

On the north of the river at the Compañía Nacional Carbonífera pits, there is a very striking change; only five seams exist, which, with the strata overlying,



Top works, Errazuriz Mine

are of such different appearance and thickness as to make them difficult to correlate. Only in the bottom seam has any extensive work been done here. The seams on this side dip N. 20 degrees W., while on the south, at Errazuriz, they dip S. 70 degrees E. At Victoria mines, on the other side of the fault, the dip is more or less S. 80 degrees W. The general inclination of the strata is about 18 degrees.

#### BAD FAULTS OCCUR

That the district has been subject to serious disturbing influences is very evident from the way the strata are broken up by the numerous faults that cross the coal field. The more important of those faults have a general north and south direction, although there are others of considerable size, running in other directions. This, combined with the series of short folds running east and west, appears to indicate that the line of greatest force has been exerted in the same direction (E. & W.). Indications of pressure from north and south are not absent, as can be seen from the anticline which most probably had its crest somewhere about the south bank of the river Lebu.

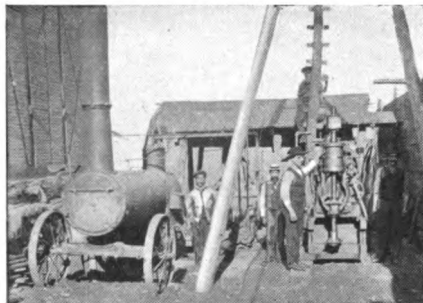
The strata from the surface to the coal are composed mainly of quartzose sandstone interbedded with clay shales. In some parts the quartz grains of the sandstone attain considerable size, giving it almost the appearance of shingle. These

beds, which are of great thickness, as a rule overlie the coal; the only exception being the bottom seam at Errazuriz, where the roof is a gray sandy shale, with small particles of silvery mica showing in the bedding planes. What may have been glacial action is represented by a boulder bed three meters thick, four meters above the first, or topmost seam of coal. The coal seams have the cleavage planes very close together, the coal not parting readily from them, so that it is immaterial whether the seams are worked "bordways" or "end on." The "bordways" facings of sparry glance, so common in the north of England, are unknown here.

The coal from this part of the Chilian coal field gives good results in steaming; it burns with a long flame, leaves a moderate amount of ash, but gives off considerable smoke. Attempts to coke this coal have met with no success. An attempt made by the writer, who has had no experience in coke making, gave as a result a steely gray powder with pieces having the appearance of charred wood.

#### MINING SYSTEMS

All the seams in the district are worked upon the longwall system, except the bottom seams in the Victoria and Errazuriz mines. The first-named firm works on the "bord and pillar" plan, while at the latter, a system of panel work is in use, owing to the presence of gas and its liability to cause spontaneous combustion.



Sullivan "B" Diamond Drill at the Errazuriz Mine

This system was adopted at Errazuriz in the year 1885, when a fire which broke out in this seam reached such serious proportions that the pit had to be temporarily flooded.

Cross-measure drifts in stone are driven from the levels in the seam next above this, which is really composed of four seams, with an average total thickness of nine feet. The "bords" and "walls" of the panel are driven in the two center seams to form a square of work of about one hundred yards; the pillars of which are afterwards robbed, cribs of five-foot props, filled with rubbish, being left in to support the roof and prevent injury to the levels above. The panels are afterwards isolated by wooden dams built in the cross entries.

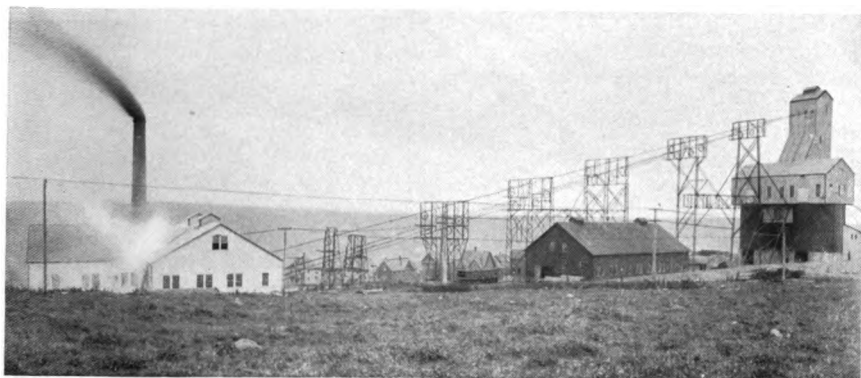
Some of the old abandoned panels were opened up some months ago, with the object of getting more coal, and it was found that the pressure has brought the upper and lower seams so close together as to permit them to be worked as one seam. As yet no gas has been discovered, neither has there been any indication of spontaneous ignition. Care is, however, being

taken to keep the work isolated in case fire does break out. All coal in this field is undercut by hand pick, and is very soft and easy to mine. No seams less than 80 centimeters in height are worked. The accompanying photograph shows the mine buildings at the Errazuriz Mine.

Perhaps it would not be out of place here to mention that the earthquake which, on the 16th of August, 1906, almost destroyed Valparaiso, did not affect the Chilian Mines. Although a distance of only 300 miles as the crow flies from the center of the disturbance, the shock was felt only on the surface. A hanging lamp in the engineer's house swung gently to and fro like the pendulum of a grandfather's clock. The night shift men were in the mine at the time, but inquiries made among them soon after the shock brought out the fact that it was not felt in the mine. Nothing occurred either at the Coronel or Lota mines, which are 60 miles nearer Valparaiso; Chile is frequently subject to these earth tremors and scarcely a week passes without one of them being reported.



Prospecting for Coal and Iron in Central India with a Sullivan Hand Diamond Core Drill



Power Plant and Shaft House, No. 2 Shaft; Hancock Consolidated Mining Co.

## A LAKE SUPERIOR MINE PLANT

SURFACE EQUIPMENT OF THE HANCOCK CONSOLIDATED MINING CO.

By W. J. PERKINS<sup>1</sup>

The Hancock Consolidated Mining Company of Hancock, Mich., has had in operation since March of last year what is in many respects the most complete and modern surface equipment in the copper mining district of northern Michigan.

### HISTORY

The old Hancock mine was opened in 1859, in what is now the center of the City of Hancock. These early workings, now known as shaft No. 1, extended to a depth of a little over 1,000 feet in the Sumner amygdaloidal beds. Work in this mine was carried on until 1886 and about 6,000,000 pounds of copper were produced. At that time, the mine was closed, owing to the low price then prevailing for copper. Twenty years later, in 1906, the Hancock Consolidated Mining Company was organized with John D. Cuddihy as President, John L. Harris as General Manager, and F. G. Schubert as Superintendent. Operations were renewed in the old or No. 1 shaft, and in December, 1906, ground was broken for shaft No. 2.

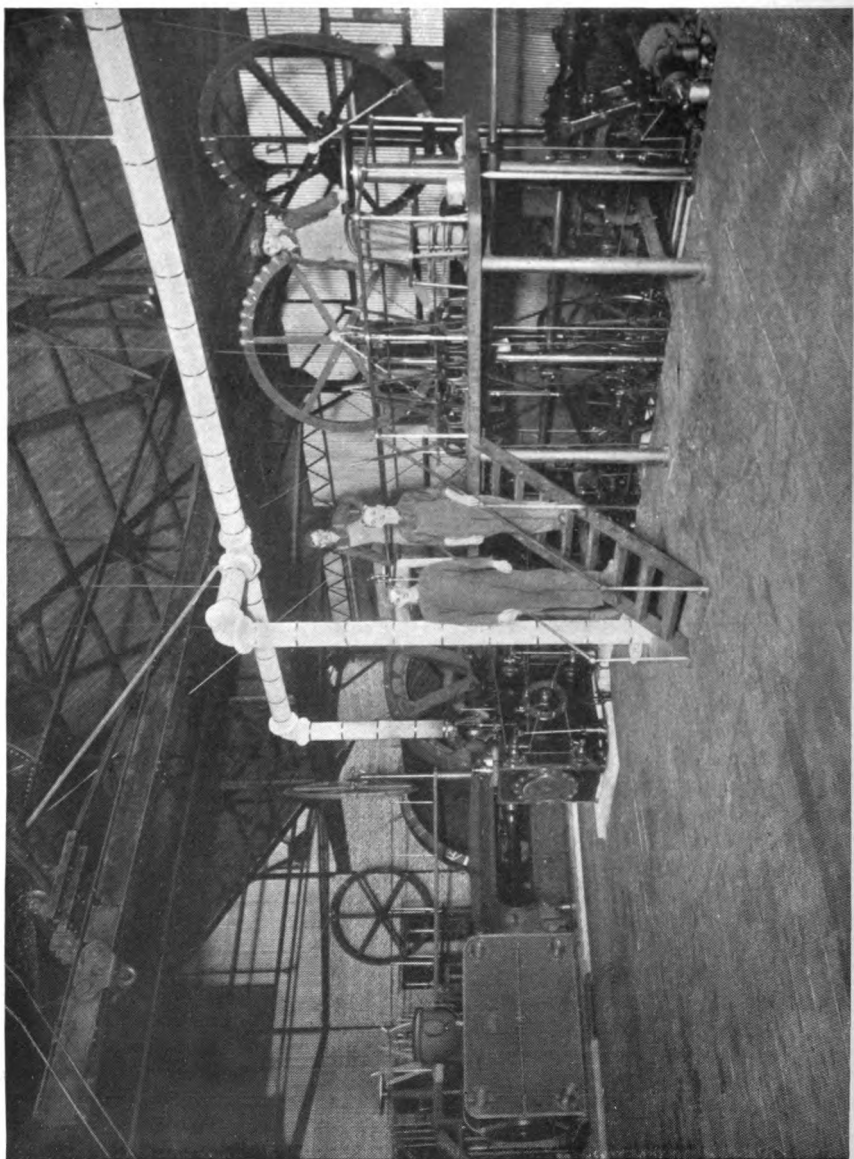
<sup>1</sup> Houghton, Mich.

### SHAFT No. 2

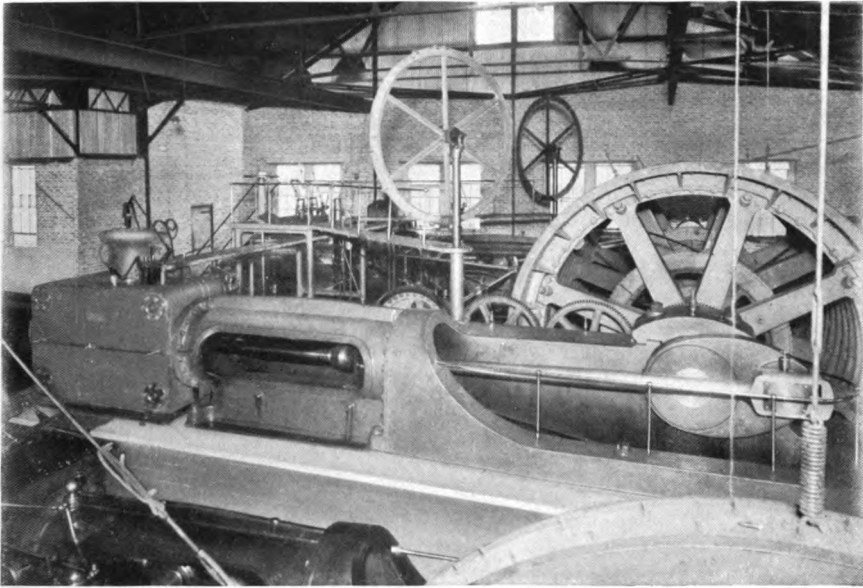
This is a five compartment, vertical shaft. Its outside dimensions are 9 by 30 feet and it is the second largest shaft in the Lake Superior district. It is now completed to a depth of 3,300 feet, and its present objective point is the Pewabic lode, which it is expected will be struck at a depth of 3,600 feet.

Shaft No. 2 has a collar of solid concrete extending 40 feet below the surface. This concrete is 24 inches thick at the top and 30 inches thick at the bottom.

The rockhouse at shaft No. 2 is a modern structure of steel, 128 feet high, with the working floor 64 feet above the ground. The shaft buildings are shown in the illustration on this page. There are two steel ore bins 38 feet in diameter, holding 900 tons of rock each. In the rockhouse are installed two crushers with a capacity of 1,200 tons of ore per day. These crushers have jaws 24 by 36 inches and each is fed by a steel belt conveyor five feet wide and seventeen feet between the sprockets. The conveyors have a section with slots



Sullivan Hoists at the Hancock Consolidated Mining Co., Hancock, Mich. In the foreground, double drum hoist, now used as auxiliary. In the background, single drum, main hoist



First Motion Sullivan Corliss Hoist, side view. This shows reverse mechanism and internal auxiliary rope reel inside the main drum, for taking up and paying out cable

and cross-bars, giving an opening of two inches square, to form a grizzly for small rock to pass through.

The crushers are driven by 50 horsepower motors and the conveyors by ten horsepower motors.

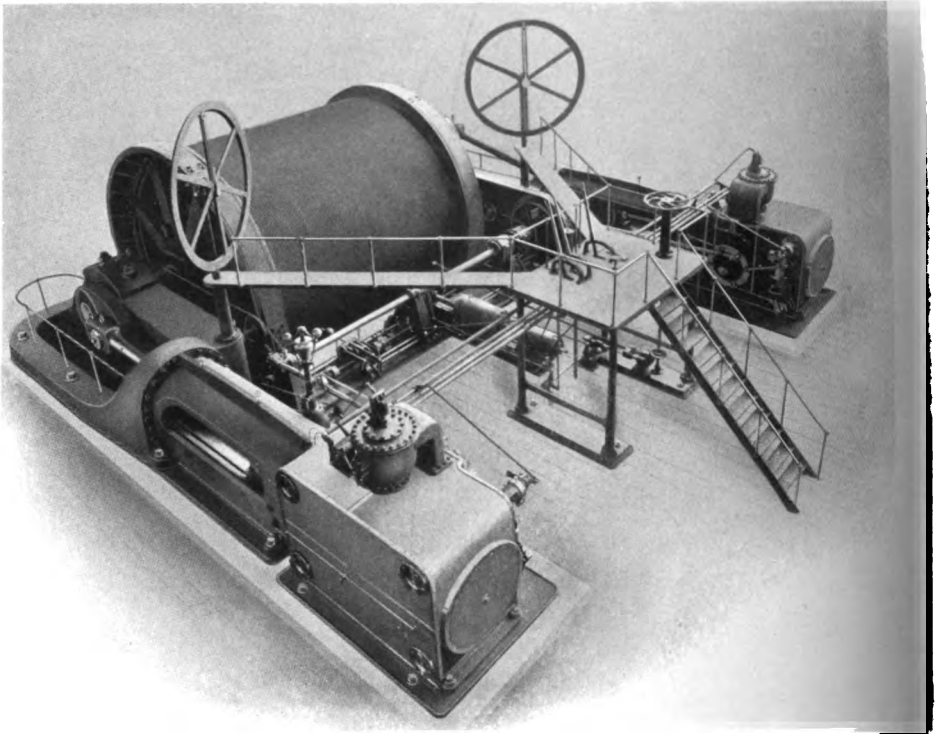
The boiler house is built of steel and is 56 by 98 feet in area. (See page 594.) It contains two batteries each, of four 150 horsepower return tubular, fire tube boilers, each 72 inches in diameter by 18 feet long. Standard gauge railroad coal cars are run into the building and the coal dumped into bins directly in front of the boilers. The capacity of the bins is 250 tons. The stack is built of reinforced concrete and is 125 feet high and 12 feet 8 inches in diameter at the base.

The engine house is also of steel, with a ground area of 60 by 94 feet, and contains the two hoisting plants. The three air compressors are installed in a wing 50 by 50 feet in area.

#### HOISTING ENGINES

The first hoist installed for sinking purposes was a Sullivan first motion, double drum Corliss plant, and has been in operation since 1906. This plant consists of two 24 × 48 reversible Corliss engines, operating through friction clutches two drums, each eight feet in diameter by nine feet long. The drums are machine threaded. This plant has a capacity of hoisting from a depth of 4,000 feet at a speed of from 2,000 to 2,500 feet per minute. Each drum handles two Kimberly skips in balance. The net load, exclusive of the weight of the rope, is 10,000 pounds. This plant is now used as an auxiliary to the main plant, and ordinarily handles men and timbers only.

In 1910, a second or permanent hoisting plant was installed, also of Sullivan design and construction. This consists of two 36 × 72-inch simple Corliss reversing engines, which are keyed to the shaft of a 15 × 15-foot straight-faced



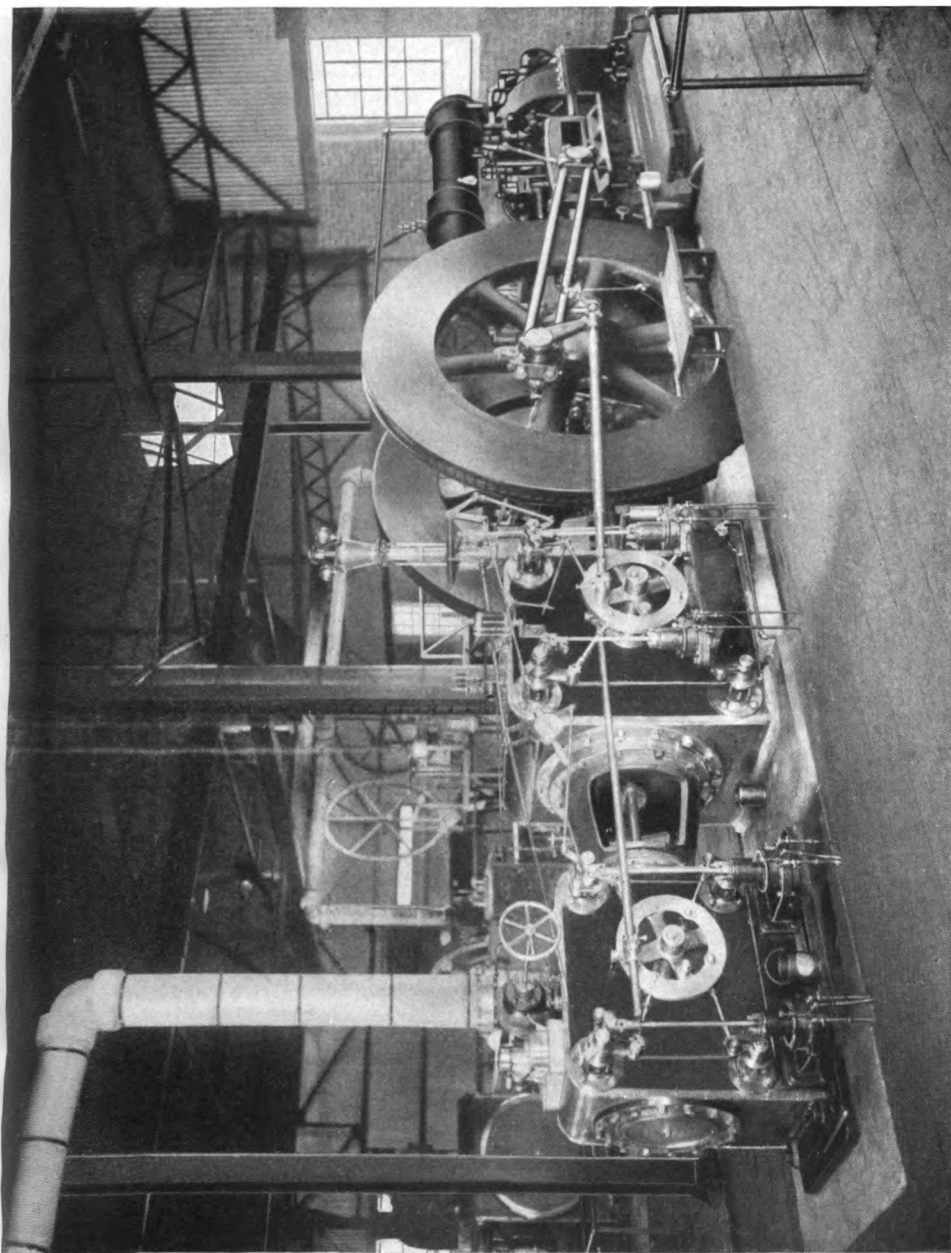
View of Sullivan Corliss Hoist at Hancock Consolidated Mining Co. The automatic throttle-closing device and automatic brake control are in front of the drum at the left. (From a factory photograph)

drum, machine threaded. This hoist operates two skips in balance and has a capacity of lifting eight tons of rock from a depth of 4,000 feet at a speed of 3,500 feet per minute. The cages have Kimberly skips swung under and weighing five tons. Both of these hoists exhaust into a 3,000 horsepower feed water heater, which heats water to 190 degrees; they take steam from the boiler plant at 150 pounds pressure.

#### SAFETY DEVICES

Both hoists are equipped with safety appliances of the most improved pattern. These consist of an automatic throttle-closing device, by means of which the main throttles are closed automatically at a point in the hoist, previously determined,

at which the mechanism is set to act. After this device goes into effect, it is impossible for the engineer to open the main throttles until the engines have been reversed for the down trip. This mechanism relieves the engineer entirely of judgment as to the point in the hoist at which the throttles should be closed. For short movements of the hoists, or in case varying load should cause the skip to come to a stop before reaching the dump or the level desired, small bypass throttles are provided which enable the engines to be turned over and bring the hoist slowly to the desired point. In case the engineer should neglect to apply his brake, at the proper point, after the throttles have been closed, an automatic brake is provided which goes into effect at a predetermined



Sullivan Tandem Compound Two stage Corliss Air Compressor, Hancock Consolidated Mining Co., Hancock, Mich.



Another View of the Hancock Power Plant

point before the landing is reached. This device absolutely prevents an overwind, with the serious consequences which such an accident would entail. When this automatic brake goes into action, it is impossible to release the brake or to move the hoist until the reverse lever has been thrown for the return trip. In the double drum hoist, there is a separate automatic throttle closing device and automatic brake for each drum, so that each can act and be governed independently of the other. In this hoist, the automatic brake is locked in position when set, by means of a blocking mechanism which must be released by hand before the engineer can move the hoist.

#### AIR COMPRESSORS

When operations were resumed in 1906, the company installed a Sullivan straight line, two-stage air compressor with simple slide valve steam cylinder controlled by Meyer adjustable cutoff. This is of the class WB-2 pattern. The steam cylinders are 22 by 24 inches in size, and the air cylinders 24 by 14½ by 24 inches. The rated capacity is 1,300 cubic feet of free air per minute. This was used for shaft

sinking and development, until 1910, when the company installed a Sullivan Tandem Corliss compound two-stage air unit, class "WC" with a capacity of 2,450 cubic feet of free air per minute. The steam cylinders are 20 and 34 inches by 30 inches; air cylinders, 18 and 30 inches, by 30-inch stroke.

The high and low pressure steam cylinders of this compressor are equipped with full Corliss valve gear, actuated by dash-pots, the point of cutoff being under the control of a speed and pressure regulator of simple design, which depends for its action on both the steam and terminal air pressure. The air inlet valves on both these units are of the semi-rotary Corliss pattern, actuated by independent eccentrics on the ends of the shaft. The air discharge valves are of special automatic poppet design and are located in the cylinder head. They are very simple in construction and easily moved. They can be removed for inspection and cleaning together with their removable cages. The intercooling area in these machines is unusually large.

The compressor house also contains a cross-compound Meyer valve gear compressor with two-stage air cylinders, having a capacity of 1,700 cubic feet of free air per minute. All of these compressors are operated condensing. The Corliss tandem unit is connected to a jet condenser and the WB-2 and cross-compound machines with barometric condensers. The Corliss tandem compressor is shown in the photograph on page 593.

The writer is indebted to Mr. F. G. Schubert for his assistance in preparing these notes.

#### STOPPING DRILLS IN A TUNNEL

The accompanying photograph shows how Sullivan stopping drills were used recently to good advantage by a contractor, in a railroad tunnel.

In driving the second Kingwood Tunnel,

on the Baltimore and Ohio Railroad, between Tunnelton and Grafton, W. Va., Messrs. Bennett & Talbott, the contractors, sank three shafts and worked six headings at once. The bore inside

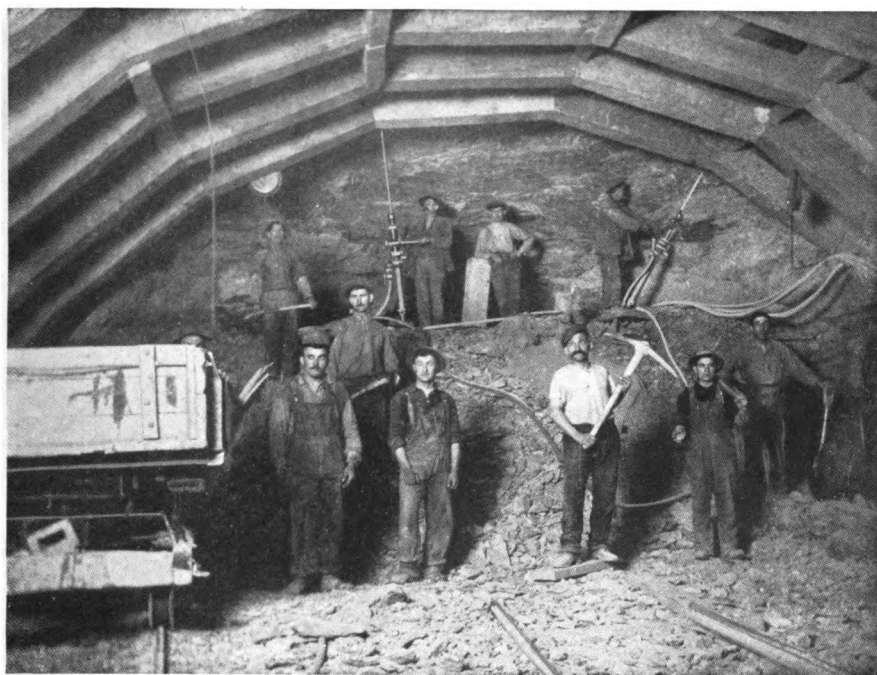
the lining is 31 feet wide and 24 feet 6 inches high above the rails. It carries two tracks. At first, top headings, about 7 x 12 feet were driven, the sides being trimmed and the bench shot to the wall plate grade, which was 17 feet above the sub-grade of the finished tunnel. This method was not entirely satisfactory, as the rock broke in such a way that close timbering was necessary to prevent roof falls.

Headings were then driven instead, about six feet high and 10 to 12 feet wide, on the wall plate grade. This left about six feet of roof and the sides to be removed, before placing timbers. This plan made it possible to carry the timber much closer to the breast; and the labor and expense previously incurred in erecting stagings for setting the heavy roof beams were dispensed with.

Sullivan stopers were used for drilling the roof holes, and for trimming the side walls when timbers would not clear. In this work they proved rapid and convenient, and the fact that no mounting is needed for drills of this pattern, accomplished a considerable saving in time and labor. The bench was excavated by two steam shovels.

This tunnel is 4211 feet long, and was driven from portal to portal in 14 months. The brick and concrete lining is now well advanced, and it is expected that the new tunnel will be in use about May 1st of this year.

A complete description of methods and progress on this tunnel, by Mr. E. M. Graham, resident engineer, appeared in Engineering Record of Feb. 10 and in Engineering News of Feb. 8.



A Heading in the Kingwood Tunnel, B. & O. Railroad; Sullivan Stopping Drills putting in roof holes

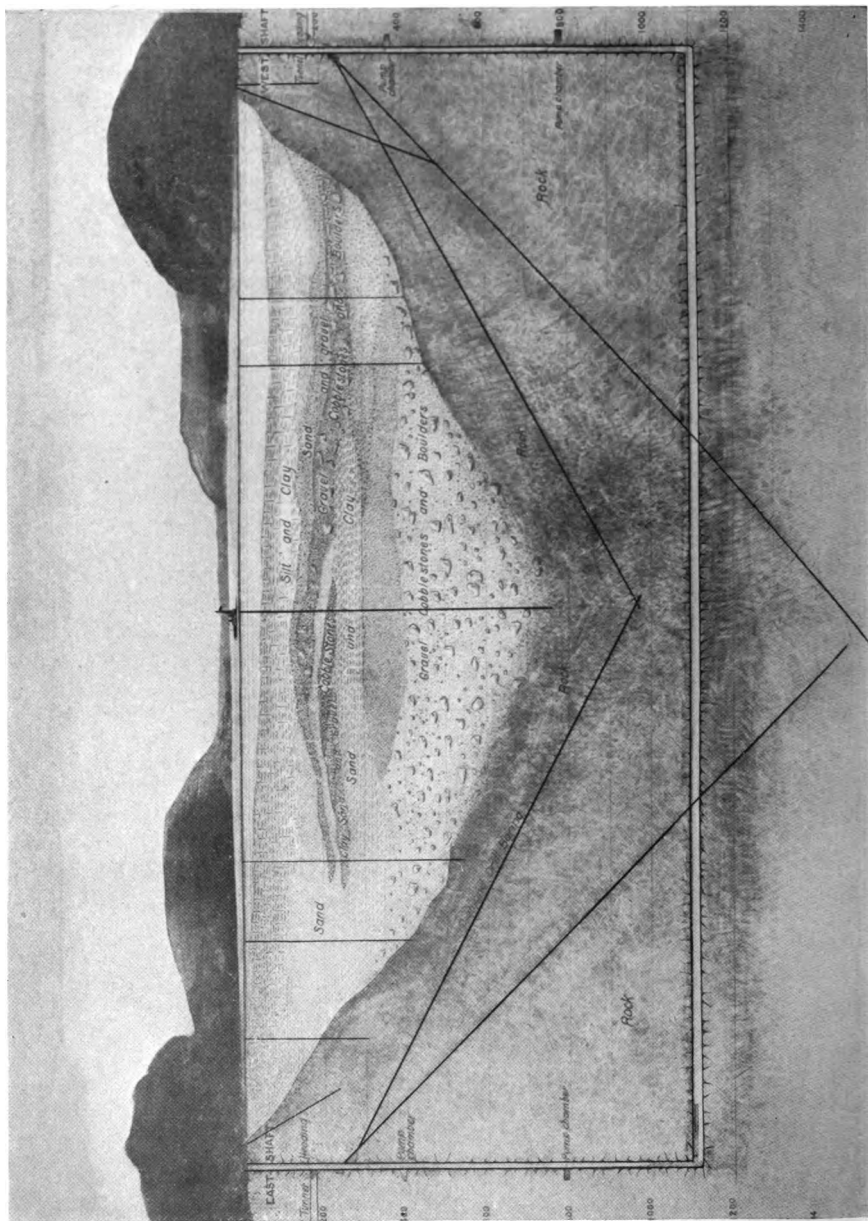
Storm King

Crow's Nest

West Point

Bull Hill

Breakneck Mtn.



Sectional view of the Hudson River Valley at Cornwall. The Tunnel is 3022 feet long; the central vertical diamond drill bore hole is 768 feet deep; the upper pair of inclined holes are 1650 and 1051 feet long, and the lower pair, 1834 and 2051 feet long, respectively.

## THE HUDSON RIVER CROSSING OF THE CATSKILL AQUEDUCT

By JOSEPH H. BROWN, JR.<sup>1</sup>

The most important, and in many ways the most difficult, section of the new Catskill Aqueduct, which is to supply New York City with water from the Catskill watershed, 150 miles away, is the deep pressure tunnel or inverted siphon under the Hudson River. After a long and careful study, in which the foremost engineers and geologists of the country participated, the narrow gorge, where the Hudson River passes between Storm King and Breakneck Mountains, was selected for the crossing. At this point the river is about 3000 feet wide, and the hills rise abruptly almost from the water's edge. The river is 40 feet deep in mid channel, but it was expected that many feet of sand and boulders lay above the rock, although there was every indication that solid rock occurred at a depth not too great to make the crossing practicable. The judgment of the men who selected this crossing was recently vindicated by the "holing through" of the tunnel, for which Mayor Gaynor fired the final shot on January 30th. The way is now clear for the new water supply, and all that remains to complete the siphon is the concrete lining, which is being rapidly put into place. This enterprise has been accomplished by means of Sullivan Air Compressors, Rock Drills and Diamond Drills, each doing its part in the construction of the shafts and tunnels.

## PRELIMINARY WORK

Work was actually started on the crossing in the spring of 1907, when the Cranford Co. of Brooklyn, N. Y. began sinking two test shafts, one on each side of the river on the line of the siphon. Although this was in the nature of experimental work, the engineers were so certain of the ultimate success of the project that the circular shafts were made

full size (17 feet in diameter) so that they might serve respectively as down-take and up-take for the tunnel, to be driven nobody knew just how far below the surface.

At the same time, core borings were started from scows in the river, and it was hoped that the casings would be driven to rock and actual bed rock located, before the shafts were down any considerable distance. The formation in the river gorge proved to be very difficult, however, and collisions with the river traffic so often undid months of hard work, that after numerous attempts, this method was abandoned. These borings went so far as to show, nevertheless, that the rock bed was at least 750 feet below water level. The deepest hole bored in this way attained a depth of 768 feet.

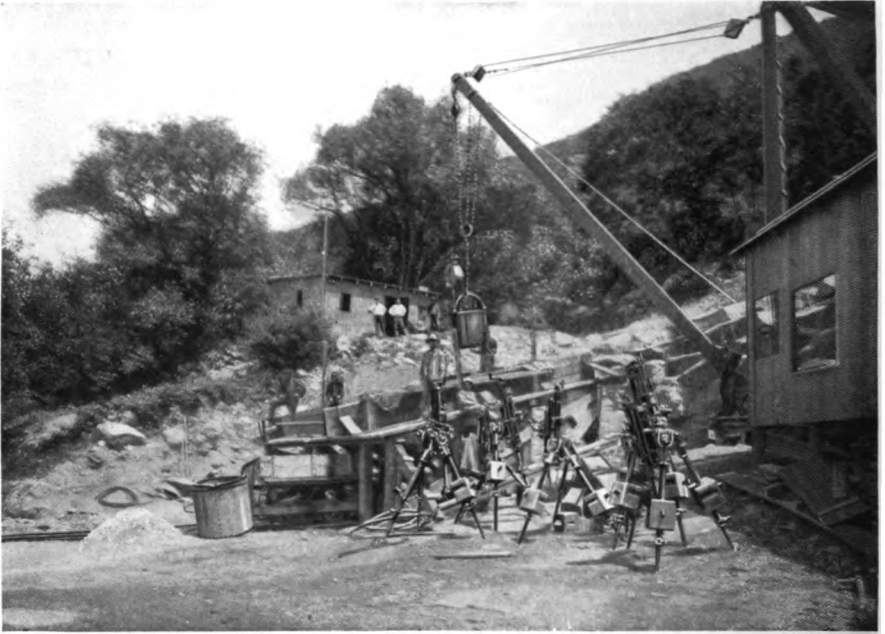
Meanwhile, work on the test shafts progressed steadily. The contractors' plant has already been described in MINE AND QUARRY for August, 1907. Briefly, it consisted of three Sullivan "Class WB2" straight line, two-stage steam driven air compressors, each having a capacity of 1160 cubic feet of free air per minute; about 20 Sullivan rock drills of two sizes, "Class UF2" (3¼ in.) and "Class UH" (3⅝ in.), and a number of Sullivan "Class DB-15" hand feed hammer drills.

After it became evident that the shafts must be sunk to a great depth, the city decided to take over the work; and Mr. William E. Swift, Division Engineer, was placed in immediate charge of the construction. The city also took possession of the contractor's plant, and purchased additional Sullivan rock drills.

## DIAMOND DRILL BORINGS

In order to determine the depth at which solid rock existed under the river, inclined borings were started with Sullivan

<sup>1</sup>Hudson Terminal Bldgs., New York.



Starting the shaft on the Storm King side: Sullivan Drills in the foreground



Mayor Gaynor and his party in the "holed-through" tunnel, 1100 feet below the Hudson. Mayor Gaynor is the second man from the right, front row, rear group

Class "B" and Class "C" Diamond Core drills from chambers in each shaft, at about the 250-foot level. The chambers were offset from the shafts, so as not to interfere with shaft sinking, which went on without interruption.

Great care was taken to measure the direction, depth and inclination of the holes, and the first pair crossed in solid rock at a depth of approximately 1500 feet. Another pair of holes was immediately started, and these crossed at 955 feet, also in sound granite. It was, therefore, established that solid rock was present at that depth at least, and a tunnel grade of 1100 feet below water level was decided upon, insuring a roof at least 140 feet thick and probably from 250 feet to 300 feet in thickness.

#### DEEP SHAFT SINKING

No unusual difficulties were encountered in sinking the shafts, other than the extreme hardness of the granite formation and the "popping" of the rock. Rock, apparently solid, frequently cracked off from the walls with little warning, and it became necessary to put in steel linings, which were kept down very close to the bottom. Considerable water was struck at various times, but was either sealed off or taken care of by the large pumping equipment.

#### TUNNEL DRIVING

When the shafts were down to tunnel grade and the headings turned, the engineers considered that the experimental work was completed, and bids were asked for the construction of the tunnel. Particular attention was called to the importance of the work, to the necessity for rapid progress (this point being of special interest on account of a threatened water famine in New York City) and to the possible difficulties and dangers, should the tunnel cut an open seam leading up to the river.

The contract was awarded to the T. A. Gillespie Co., and under its terms the entire plant on the work became the

property of the contractor. Work was started early in July, 1911, under the direction of Mr. John Dillon, Superintendent.

Additional Sullivan rock drills were purchased, these being of the "UH-2" ( $3\frac{5}{8}$  inch) differential valve type, a drill specially designed for tunnel work, of large cylinder bore, to give the necessary power, but weighing only 345 pounds, and no longer, over all, than an ordinary  $3\frac{1}{4}$  inch machine.

To guard against the danger of an in-rush of water, a large pumping plant was installed, containing both electric and air-driven pumps, and as a further precaution, a massive concrete bulkhead was built a short distance in from the East shaft. A pilot hole was drilled in advance of each round of holes, and in some places, diamond drill holes were bored, which were filled with grout, forced in under heavy pressure, in order to cut off water bearing seams. Some water was struck, but not enough to interfere seriously with the work.

The tunnel was driven all the way through solid granite, and is 17 feet in diameter, giving a finished bore of 14 feet 6 inches, inside the concrete lining. The west heading was driven 1744 feet, or at the rate of 265 feet per month, while the rate for both headings was over 360 feet per month, and the total length driven under this contract more than 2500 feet. This progress is very creditable to the contractors and to the methods employed, under the difficult working conditions. It should be recalled that all spoil had to be hoisted and all material and tools lowered through shafts 1100 feet deep.

Articles describing the details of the diamond drilling work were published in Engineering News for April 2, 1908, April 7, 1910 (by William E. Swift, division engineer, N. Y. board of Water Supply), and March 23, 1911 (by Alfred D. Flinn, Department Engineer, at New York).



Sullivan Diamond Core Drill in west shaft station. This photograph and the others which illustrate this article were furnished by the courtesy of the Board of Water Supply

#### NOTES FROM THE DIAMOND DRILLMAN'S LOG

The squeezing or filling up of a drill hole in certain rocks is nothing new, and many old drill men can give interesting experiences of such occurrences. In drilling for coal in Iowa, stand pipe and casing were put in to a depth of 35 or 40 feet and the drill then passed through 80 or 90 feet of shale. Below the shale was a porous, free-drilling sandstone, 100 or 125 feet in thickness. This was cut very rapidly; 85 feet of core being removed in a single shift's work. The drilling was carried on during the day shift only and after passing through the sandstone, the drill foreman, on lowering his tools, one morning, found an obstruction in the hole, just below the standpipe. Thinking

that a dirt cave had filled the hole, or that the standpipe had been shifted by pressure, he started his engines, and was surprised, on pulling up after a foot of drilling, to find that the core barrel contained a foot of shale core. He continued his work and was obliged to drill through the entire deposit of shale which he had penetrated a few days previously, getting full core all the way, and encountering no trace of the old hole. On reaching the bottom of the shale deposit, he of course expected to encounter the sandstone and to drill rapidly through it as before. To his surprise he encountered no resistance whatever. The drill had hit the mouth of the old hole in the top of the

sandstone exactly, and the tools passed through the entire layer without turning the engine or removing any core whatever. This remarkable fact is thoroughly vouched for, and is a striking example of the accuracy of the diamond drill.

### HAMMER DRILL USES

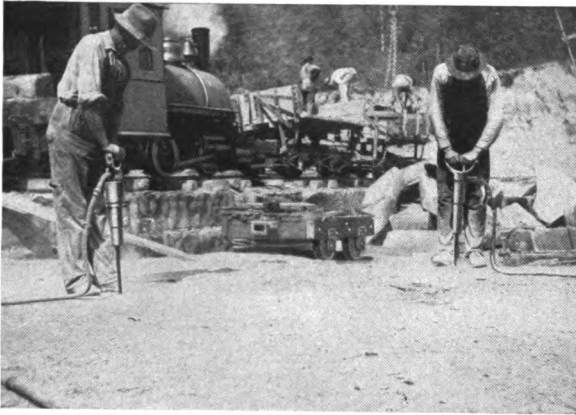
Waller Brothers Stone Company, of McDermott, Ohio, employ Sullivan hand feed hammer drills in a number of ingenious ways, for quarrying sandstone and shaping the work before finishing it in their mills. The photograph on this page shows two of these tools at work. The small cut on this page illustrates two sections of a salt still ten feet high, being loaded on a car for shipment.

These sections were cut from solid

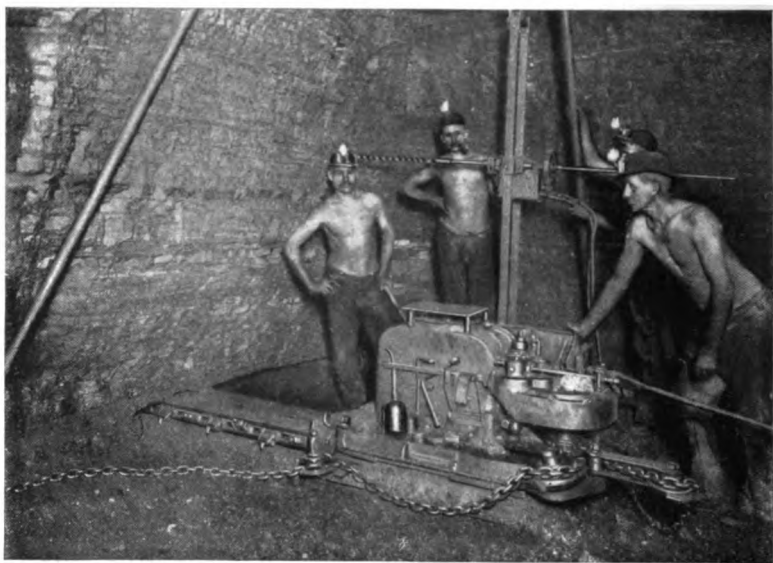


Sandstone rings for a salt still

blocks of stone and have an inside diameter of four feet. The cores were removed with the hammer drills, greatly reducing the time and labor formerly required when hand tools and hammers were used.



Sullivan Hammer Drills at Waller Bros. Stone Co.'s Quarry, McDermott, Ohio



## Sullivan Coal Cutters

of the continuous cutting chain type, have shown by test that they are the most rapid machines made for mining coal, and that they cost less for power, per ton, or per square foot, than any other coal cutter.

NEW BULLETIN, 163F

Sullivan "C E" Continuous Cutter in the Blackheath Colliery, Bundamba, Queensland, Australia. (The machine has been run out from below the coal to show the cutter bar.)

**Fans      Pick Machines      Post Punchers      Hoists**

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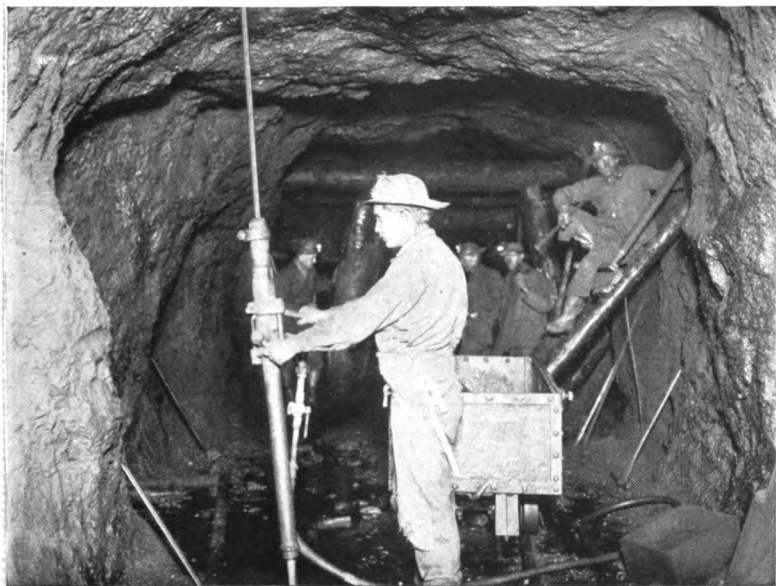
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# MINE AND QUARRY

VOL. VI. NO. 4

JUNE, 1912

WHOLE NO. 22



A SULLIVAN STOPPER BEGINNING AN UPRaise

**AIR COMPRESSOR ECONOMY**

**VERMONT MARBLE**

**COAL COST PER YARD  
OF ROCK**

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# MINE AND QUARRY

VOL. VI. No. 4

JUNE, 1912

WHOLE No. 22

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## AIR COMPRESSOR ECONOMY IN NEW YORK CITY (CHAPTER II)

By F. A. HALLECK\*

Some time after the completion of the test on the direct connected air compressors, operated by Smith, Hauser, Locher & Co. on the Catskill Aqueduct in New York City, as described in the March issue of "MINE AND QUARRY," the contractors' engineer was advised by the Edison Co. that there was some doubt as to the accuracy of the *no-load* readings. The original electrical readings were taken by representatives of the Edison Co., and upon investigation it was found that the instruments used were not of the proper type to permit of accurate readings on the lower part of the scale.

No other readings except those for *no-load* were affected and of course the question of power input has no bearing on the tests for volumetric efficiency. It will be recalled that the delivery efficiencies measured by the orifice method, were

Sullivan.....	87.7%
Piston Inlet.....	79.1%

In order to check the former *no-load* readings and to correct them, if necessary, it was decided to take new power input readings at no load on both the Sullivan and Piston Inlet compressors, using properly graduated instruments.

Since the original test was made in January, the Sullivan compressors have been fitted with automatic unloading valves on the high pressure cylinders, which allow the compressors to discharge into the atmosphere any air which may

be drawn into the cylinders while the machines are running unloaded. These valves are part of the regular equipment and are in operation under ordinary running conditions, but in order to check the accuracy of the electrical instruments used in the original *no-load* test, readings were first taken with the compressor discharging against line pressure and then with the automatic high pressure unloading valves in operation.

The readings were taken by testing engineers of the Edison Co. in the presence of the contractors' engineer and representatives of both manufacturers, and the following results were obtained:

### K. W. INPUT. NO LOAD

Sullivan—

Original reading.....	32.4 K.W.
New reading, discharging against line pressure....	61.2 K.W.
New reading, with auto- matic high pressure un- loading valve.....	42.2 K.W.

Piston Inlet—

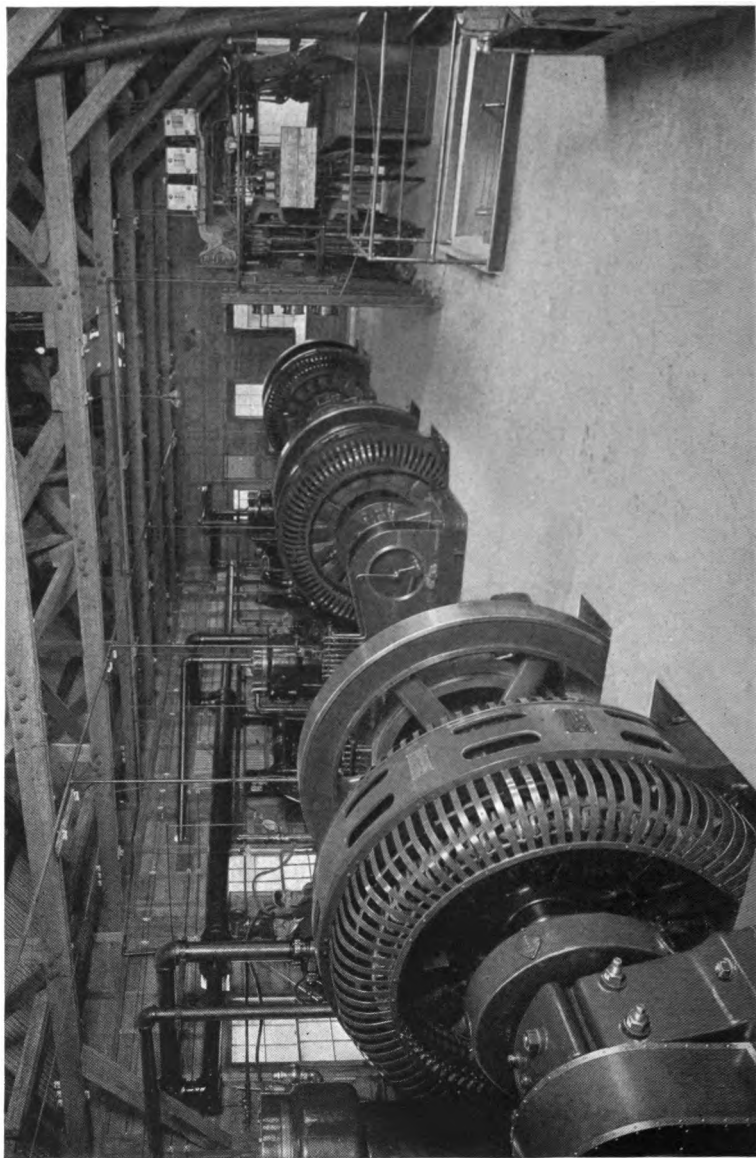
Original reading.....	43.5 K.W.
New reading.....	45.0 K.W.

In order to show the effect of the increase in the *no-load* readings of the Sullivan compressor upon the cost of operation at partial loads, the following curves have been drawn:

No. 1, on page 603, shows the results obtained from the original test as published in the former article.

No. 2, on page 605, shows the results

\*2624 West Lake St., Chicago



Sullivan "WN<sub>2</sub>" Compressors in Central Park Plant of Smith, Hauser, Locher & Co.

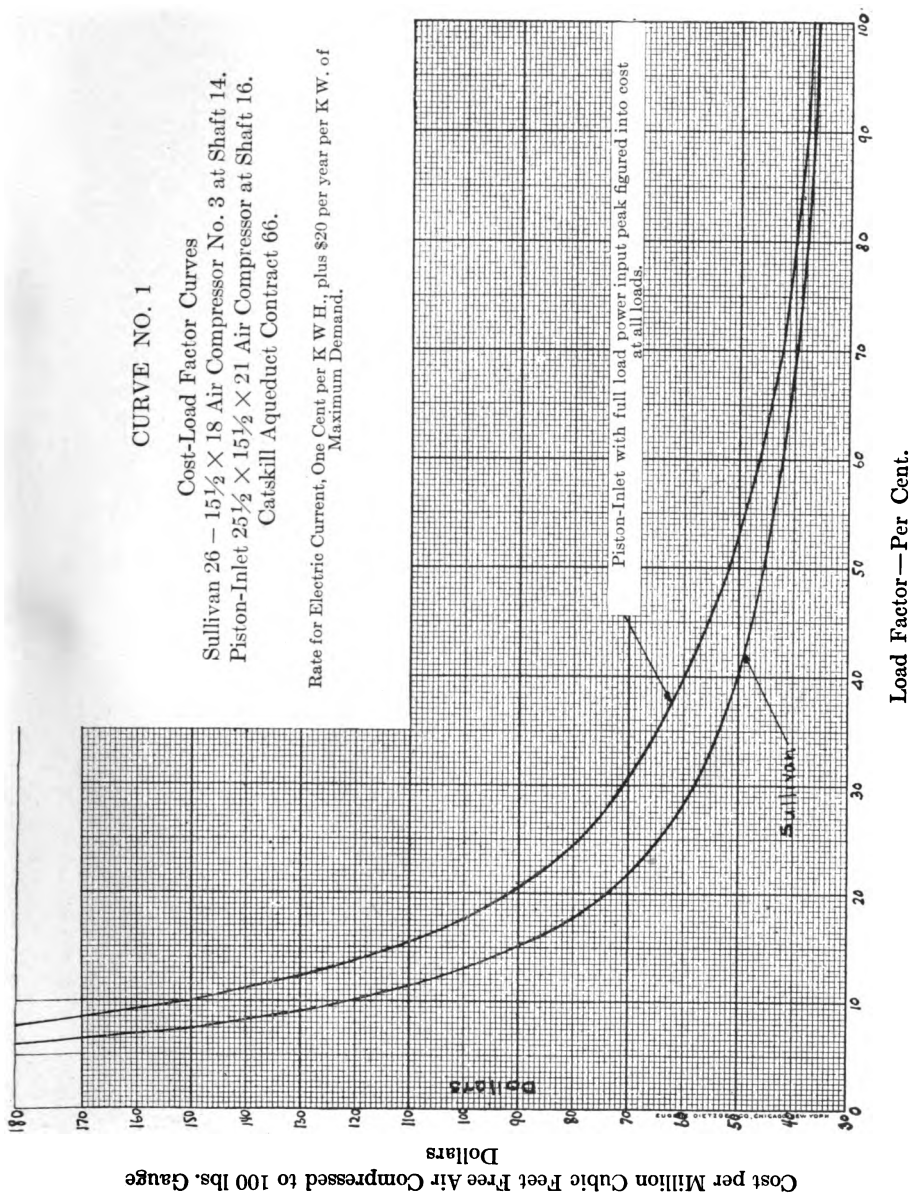
## CURVE NO. 1

## Cost-Load Factor Curves

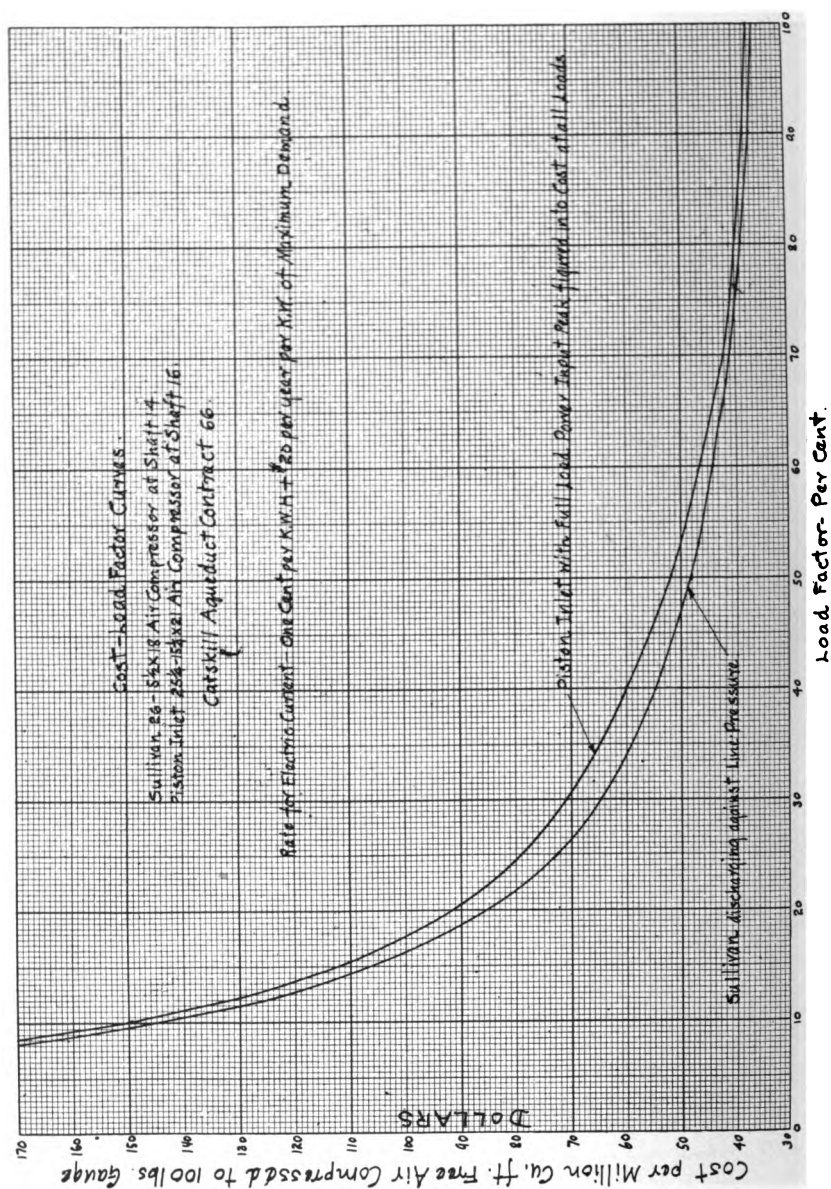
Sullivan 26 —  $15\frac{1}{2} \times 18$  Air Compressor No. 3 at Shaft 14.Piston-Inlet  $25\frac{1}{2} \times 15\frac{1}{2} \times 21$  Air Compressor at Shaft 16.

Catskill Aqueduct Contract 66.

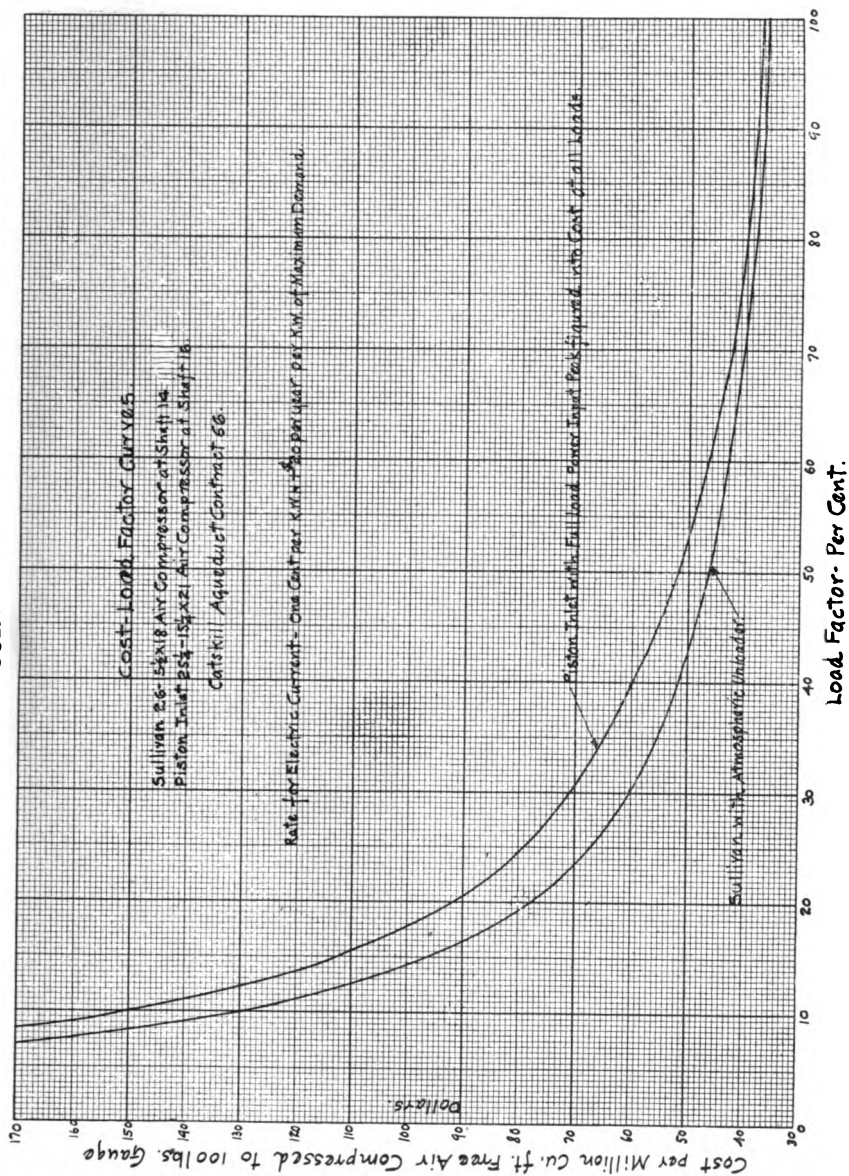
Rate for Electric Current, One Cent per K.W.H.; plus \$20 per year per K.W. of Maximum Demand.



CURVE NO. 2



CURVE NO. 3



obtained by using the no-load figure of 61.2 K. W. for the Sullivan compressor discharging against line pressure. This does not represent present actual running conditions, but is submitted to show that even without the automatic high pressure unloading valve, the cost is less than with the clearance control of the piston inlet machine.

No. 3, on page 605, shows the results obtained by using the no-load figure of 42.2 K. W. for the Sullivan compressor with the automatic high pressure unloading valve in operation. This curve represents present actual running conditions.

For the sake of comparison, the following tables are given. Table A is a copy of results as published in the former article; and Table B shows the results obtained from the revised no-load figures

with the automatic high pressure unloading valve in operation. No tabulation has been made corresponding to curve No. 2, as discharging against line pressure does not represent present actual no-load running conditions of the Sullivan compressor.

The tables show the cost of supplying the same volume of air by each outfit of three compressors for one year of 300 days at full load; three quarter; half and one quarter loads.

A comparison of the above curves and tables shows that the effect of the increase of the no-load reading to the corrected figure of 42.2 K. W. is negligible except on extremely low load factors. At 60% load factor, representing ordinary working conditions, the saving of the Sullivan plant is over \$5000.00 per year.

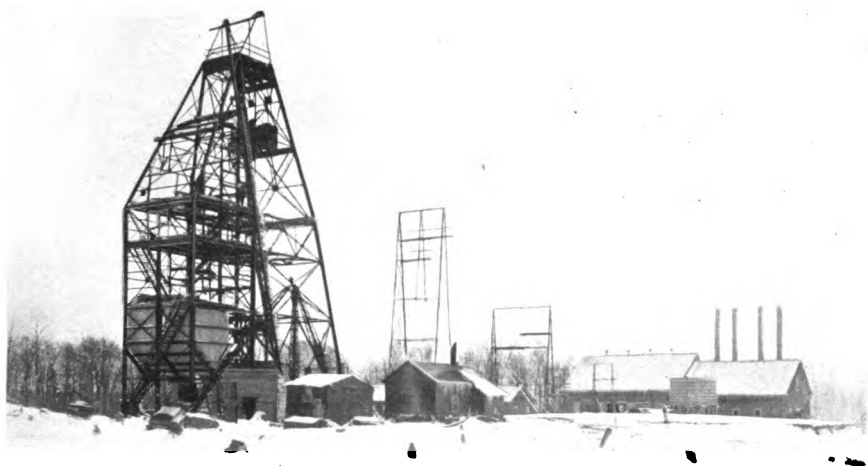
TABLE A

	¼ Load.	½ Load.	¾ Load.	Full.
Cu. ft. free air per year of 300 days.....	587,736,000	1,175,472,000	1,763,208,000	2,350,940,000
Cost per 1,000,000 cu. ft., Sullivan Compressor.....	\$64.00	\$45.00	\$39.00	\$36.00
Cost per 1,000,000 cu. ft., Piston-Inlet Compressor...	79.00	52.00	41.00	37.00
Saving per 1,000,000 cu. ft. in favor of Sullivan.....	15.00	7.00	2.00	1.00
Saving per annum, Sullivan over Piston-Inlet Compressor.....	\$8,815.04	8,228.30	3,526.42	2,350.94

TABLE B

REVISED NO-LOAD READINGS. AUTOMATIC HIGH PRESSURE UNLOADING VALVES IN OPERATION

	¼ Load.	½ Load.	¾ Load.	Full.
Cu. ft. free air per year of 300 days.....	587,736,000	1,175,472,000	1,763,208,000	2,350,940,000
Cost per 1,000,000 cu. ft., Sullivan Compressor.....	\$67.00	\$46.00	\$39.30	\$36.00
Cost per 1,000,000 cu. ft., Piston-Inlet Compressor...	79.00	52.00	41.00	37.00
Saving per 1,000,000 cu. ft., in favor of Sullivan.....	12.00	6.00	1.70	1.00
Saving per annum, Sullivan over Piston-Inlet Compressor.....	\$7,050.00	7,050.00	4,000.00	2,350.00



Head Frame and Mine Buildings, Clutts Shaft

## MINING IRON ON THE MENOMINEE RANGE

THE ZIMMERMAN MINE OF THE SPRING VALLEY IRON CO.

By J. F. BERTELING\*

An important section of the Menominee Iron Range, in northern Michigan, is that known as the "Iron River district," just north of the Wisconsin line, and centering about Iron River and Stambaugh, along the line of the Northwestern railway. Among the companies operating in this district are the Buffalo & Susquehanna Mining Co., the Brule Mining Co., Davidson Ore Co., Florence Iron Co., Verona Mining Co., Huron Iron Mining Co., Mineral Mining Co., Jones & Laughlin Ore Co., Oliver Iron Mining Co., Wickwire Mining Co. and the Spring Valley Iron Co.

### CHARACTER OF ORE

The ore found in this district is chiefly a soft red hematite, although in some places it is hydrated and classed as brown hematite. A full description of the ore beds, and of the geology of this district,

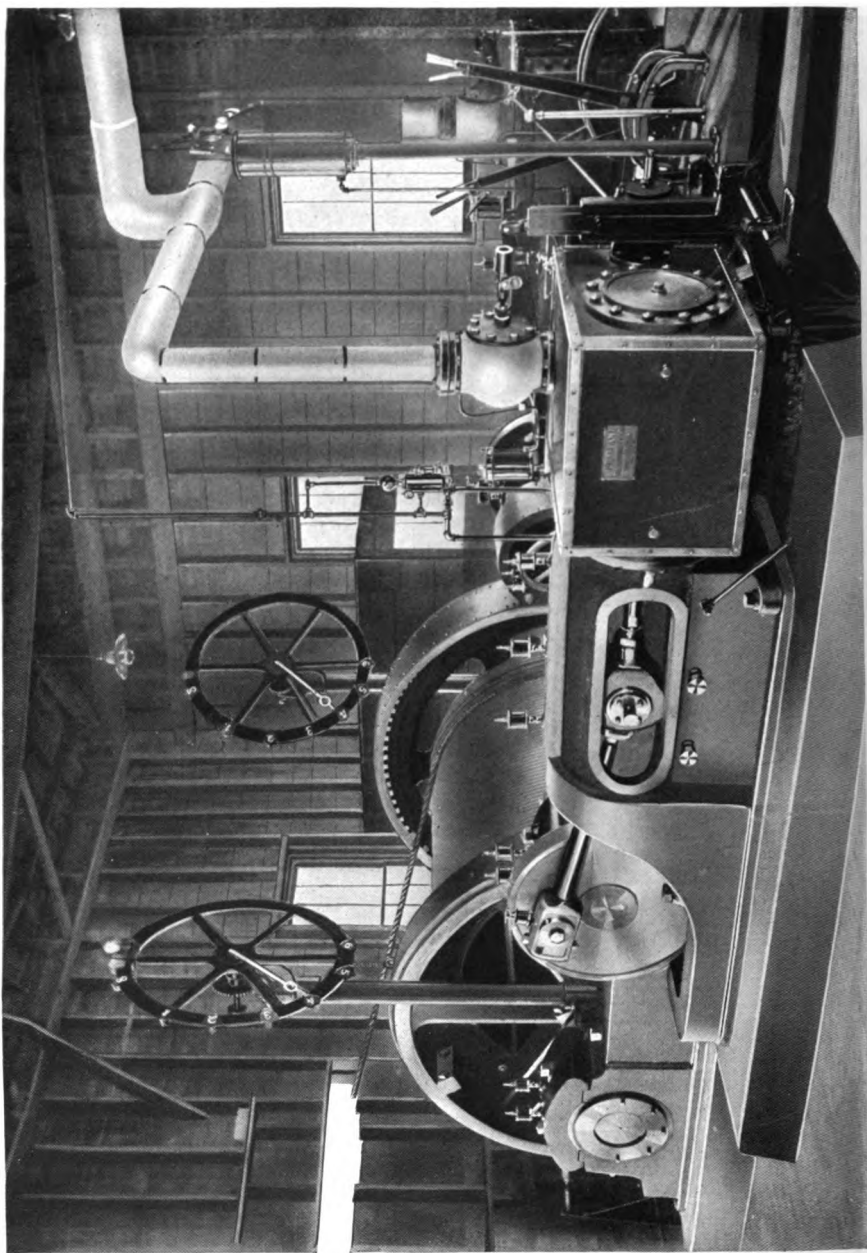
is given in monographs of the geology of the Lake Superior region, U. S. Geological Survey, Vol. 52. The average analysis of the ore produced in this district in 1909, showed 54.35 per cent of iron, and .404 per cent of phosphorus, with a range of 49.87 per cent to 56.67 per cent of iron, and .709 to 3.13 of phosphorus.

The ore shipped from this district is made into pig iron, as the high content of phosphorus makes it particularly adaptable for casting purposes.

### HISTORY OF THE DISTRICT

Mining operations in this district began in 1882, when the Riverton mine was opened, and continued until about 1893. There was a break from 1893 until about 1898, owing to the fact that the ore was of low grade, and the financial condition of the country during these years was unfavorable. Nearly all of the ore bodies

\* Ishpeming, Mich.



Sullivan Automatic Slide Valve Holst, at the No. 1 shaft of Zimmerman Mine of the Spring Valley Iron Co., Palatka, Mich.

being worked at the present time have been discovered since 1905, largely by the extensive use of diamond drills.

#### MINING METHODS

Mines in the Iron River district have not yet attained any great depth. The average is about 675 feet. Such large quantities of ore have been developed on the upper levels, that the necessity for shaft sinking, after two or three levels have been opened up, has not yet arisen. The ore is mined for the most part on the sub-level and top-slicing system, which has been frequently described in the mining journals. As a rule, the mines are dry and require little pumping, but several, located in the valley of the Iron River, have considerable water to handle, although not enough to make pumping a serious or expensive proposition.

#### SPRING VALLEY IRON COMPANY ZIMMERMAN MINE

A promising member of the Iron River group is the Zimmerman mine, owned by the Spring Valley Iron Co. and located between Palatka and Stambaugh, at the southeastern extremity of the district. The first, or No. 1, shaft was started on this property in 1906 and is at present 275 feet deep. In July, 1911, the second, or Clutts, shaft was begun. This shaft is much larger than the first one. There are two skip compartments 5 by 5½ feet, a cage compartment 6 by 9 feet, and a compartment for pipes and ladders 6 by 2 feet.

#### SURFACE EQUIPMENT — "AUTOMATIC" HOIST

The permanent surface equipment was installed at shaft No. 1 in 1910, and includes an air compressor, having a capacity of 1380 cubic feet of free air per minute, a dynamo driven by belt, a suitable battery of boilers, and a Sullivan automatic slide-valve hoisting plant, with two engines, 14 inches in diameter by

18-inch stroke, and a 6 by 6-foot drum, grooved for steel cable and driven by a gear and pinion. The engine has a range of 150 to 180 R. P. M. and the drum of 38 to 46 R. P. M., giving a hoisting speed of from 720 to 860 feet per minute. In this hoist, the admission of steam to the cylinders is controlled automatically. As the throttle is opened, steam is admitted for the full length of the stroke for the first four or five revolutions, to start the loaded skip from the bottom of the shaft. As the throttle is opened wider, however, the admission of steam is automatically cut off at the most economical point by means of an auxiliary cylinder, rack and pinion. When the throttle is closed at the top of the trip, ordinary slide valve action is resumed.

The application of the automatic cut-off to hoisting engines of the slide valve, geared pattern, is a patented invention of the Sullivan Machinery Company, and one which makes it possible to use a slide valve engine of moderate price with the same economy as an expensive Corliss model.

A continuous indicator diagram and a more complete description of the method by which this result is accomplished will be found in MINE AND QUARRY for November, 1911. The hoist at No. 1 shaft is illustrated on page 608.

Surface buildings and equipment of the most modern pattern have been installed at the No. 2, or Clutts, shaft. A view of the buildings is shown on page 607. The mine buildings include a dry house 100 by 24 feet, equipped with modern shower baths and steel lockers for two hundred men. The new machine shop is 33 by 90 feet and equipped to handle nearly every sort of a repair job that may be encountered. The steel head frame and ore pockets are shown in the foreground. The engine house is 55 by 50 feet, built on a concrete foundation. There is ample space under the reinforced concrete floor for all the pipes. This gives the engine room a very clear and roomy



Sullivan Lightweight Drill, Drilling Pillars, Zimmerman Mine

appearance and at the same time the piping is easily reached. A Sullivan automatic slide valve hoist of the same size as that at No. 1 shaft is installed here, and will run in balance, hoisting skips of three tons capacity. The Clutts shaft is not yet in commission. The hoist at No. 1 has not yet been run at anything like its capacity, either in depth or speed. At present, the production, from No. 1 shaft, runs from 600 to 700 tons per day of two shifts, hoisting with a single skip.

A smaller cage hoist is also used for hoisting men and materials, and there is a 1700 cubic foot air compressor, a high speed engine direct connected to a dynamo, to run the electric haulage motors underground, and the necessary high pressure boilers.

In building the engine house foundations, Sullivan DB-15 hand feed hammer drills were extensively used, drilling holes in the foundation. Concrete four months

old was found to be ideal material for these drills, while it was slow and laborious work for hand drilling.

#### SYSTEM OF MINING

Prior to January, of this year, the Zimmerman was distinctly a hammer drill mine. The room and pillar method of mining was employed and nearly all holes drilled in the stopes, raises and drifts were upper holes. In this work, Sullivan DA-21 air feed stopping drills were used almost exclusively, about fifteen of these machines being employed. From a record, kept over a period of several months, the average footage drilled with these machines in the stope was 60 feet per shift. Usually, drilling was not started until several hours had been spent in picking down the "loose" material from the back of the stope. When the back was solid, and drilling started early in the shift, the average footage was about 140 feet. Sullivan DB-15 hand feed hammer drills

were employed for block holing the larger chunks or fragments of ore in the stopes.

In January, for various reasons, it was decided to change the method of mining to the block caving system. The use of hammer drills in the new system is restricted to short raises, and piston drills are used almost entirely for the main work of mining.

A winze was sunk 40 feet from the original main working level and a main haulage drift was begun along the hanging wall to connect shaft No. 1 and the Clutts shaft. Cross cuts have been run from this main drift across a block of ore, which is being caved, and raises were put up to the old main working level. These raises were widened out at the top so that when the pillars supporting the block of ground to be paved were shot, the broken ore would work into them. The illustration on the front cover of this number shows a class DA-21 Sullivan stoper at work in the Zimmerman mine, starting a raise from the main working level. On page 610 is shown a class FF-12 Sullivan "light-weight" drill, of which a number are in use for drilling the pillars, drifting, etc.

The old main working level was cut up by drifts and cross cuts; the remaining pillars being drilled as the work advanced, and most of the timber removed to be used over again.

The new style "light-weight" drills, which are being used in this mine, have a

cylinder diameter of  $2\frac{5}{8}$  inches and weigh 155 pounds.

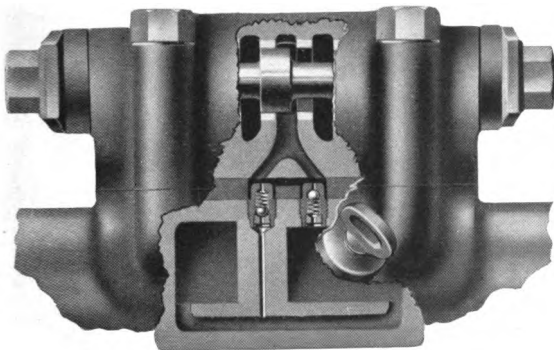
These drills require about 100 cubic feet of free air per minute at 90 pounds pressure. This is a new design which the manufacturer has recently developed and contains many interesting features which have been combined for the first time in a one-man drill. One of these is the automatic oiling device, illustrated in the accompanying picture. As will be seen, this consists of a chamber cast in the drill cylinder and holding about half a pint of lubricant. Oil from the chamber is drawn into the chest by the pulsations of the air in it. The speed is controlled by two small ball check valves screwed into the top face of the cylinder and connected by ports with the oil chamber, so that oil is conducted to the inlet opening in the chest. It is then carried through the machine in the form of a spray and insures positive and sufficient lubrication of every working part.

#### PRODUCTION

In 1909, eleven thousand tons of ore were shipped from the Zimmerman mine; in the following year twenty-five thousand; and last year one hundred and twelve thousand tons. Much of this ore was shipped to furnaces in Ohio and a large portion of it went to Detroit. This ore was produced entirely from development

work, on account of the room and pillar method of mining, which was then in use; the ore coming from drifts, raises and shrinkage from the rooms to permit working space on top of the broken material.

The writer is indebted to Mr. O. P. Doty, Superintendent, and Mr. Tom Clutts, for the information contained in this article.



Sullivan Automatic Drill Oiler



General view of the Clarendon Marble Company's Quarry

### VERMONT MARBLE (CHAPTER III)

#### RECENT MODELS OF CHANNELING MACHINES; QUARRIES OF THE CLARENDON MARBLE COMPANY, CLARENDON, VT.

By H. H. MERCER AND H. J. MARKOLF

[Methods of opening Vermont marble quarries and of extracting the valuable stone by "tunneling," without removing the tons of worthless cap rock, have already been described in detail in these columns (see footnote). This article will cover some variations from usual methods, made possible by improvements in machinery which have been developed since the earlier chapters were written.—Ed.]

Chapter I, describing the quarries and methods of the Norcross West Marble Company, Dorset, Vt., was published in *MINE AND QUARRY* for March, 1909. Chapter II dealt with the Vermont Marble Company's operations and appeared in the June, 1909, number.

#### THE CLARENDON MARBLE COMPANY

The Clarendon Marble Company was organized about five years ago as a Vermont corporation, with Mr. P. F. McCormick as president and manager and a capital stock of \$200,000.

Its quarry is situated about three miles southeast of West Rutland, and is connected with that point by a railway, built by the company.

The quarry pit is 140 x 65 feet in area, and has been opened to a depth of about 60 feet. The beds are tilted at an angle of about 45 degrees, and run back under the hill to the west. A general view of the quarry is shown above.



At the bottom of the Clarendon Quarry

The marble, of which about 300,000 cubic feet have been removed, is pure white in color, of very even texture, with but few veins or impurities. The following is an analysis, by Ricketts and Banks, of New York City:

	Per cent.
Carbonate of lime.....	97.85
Carbonate of iron.....	0.06
Carbonate of magnesia.....	0.56
Sulphate of lime.....	Traces
Silica, alumina, alkalies, organic matter and undetermined.....	1.53
	<u>100.00</u>

As indicated by these constituents, Clarendon marble is of high quality and valuable for building and monumental purposes. It sustains a heavy crushing load, and is low in absorption of moisture.

An order recently completed was for 72,000 cubic feet of stone for the New

York State Educational building at Albany. This included 23 free columns, 62 feet high and about four feet seven inches in diameter.

Some of the Clarendon marble is especially desirable for interior work, on account of its ability to take a high polish.

West of the present white marble quarry is a fine deposit of blue marble. The company's property covers a large area, and three or four additional pits can be opened whenever the demand warrants it.

#### QUARRY METHODS

The stone is quarried with an equipment which includes five Sullivan channelers and two Sullivan steel gadders.

The sketches on page 614 indicate the manner in which this quarry was opened. The pit was sunk with straight walls to

a depth of two channel cuts. With a fresh floor leveled off, two tunnel cuts were put in at an angle of 45 degrees, with a Sullivan "VW-1," duplex channeler. These cuts were carried 12 to 14 feet deep on the angle.

A double row of key blocks was then channeled across the middle of the quarry floor, the depth of the cuts and their distance apart depending somewhat on the size of blocks wanted. This work has been done largely by Sullivan Class "Z" swivel plate channelers, of which three are in use. The floor cuts are at right angles to the tunnel cuts, and are carried under the roof as far as the machines can work with standards vertical. The remainder of the cut under the roof, known as a transverse cut, and all corner channeling are done by a Sullivan "6½" channeler, equipped with a new patented corner-cutting mechanism, to be described later in this article.

The first key blocks are wedged out and pulled from the tunnel side of the quarry, as shown by the sketch below. The floor is then cut in both directions, the bottom holes, for raising, as well as the breaking holes, being drilled with two Sullivan steel gadders, carrying "UC," 2¾-inch rock drills. This process is shown in the upper or left hand sketch, on this page.

On page 616 is a photograph of one corner of the quarry, which is being carried down to the level of the main floor. This shows the tunnel cuts, the "VW-1" duplex channeler on floor work, the corner cutter channeling a transverse cut into the roof, and, in the background, a gadder, break holes and a long block being lifted out by the derrick.

#### TYPES OF CHANNELERS: DUPLEX

The Sullivan Class "VW-1" duplex channeler has been mentioned in other

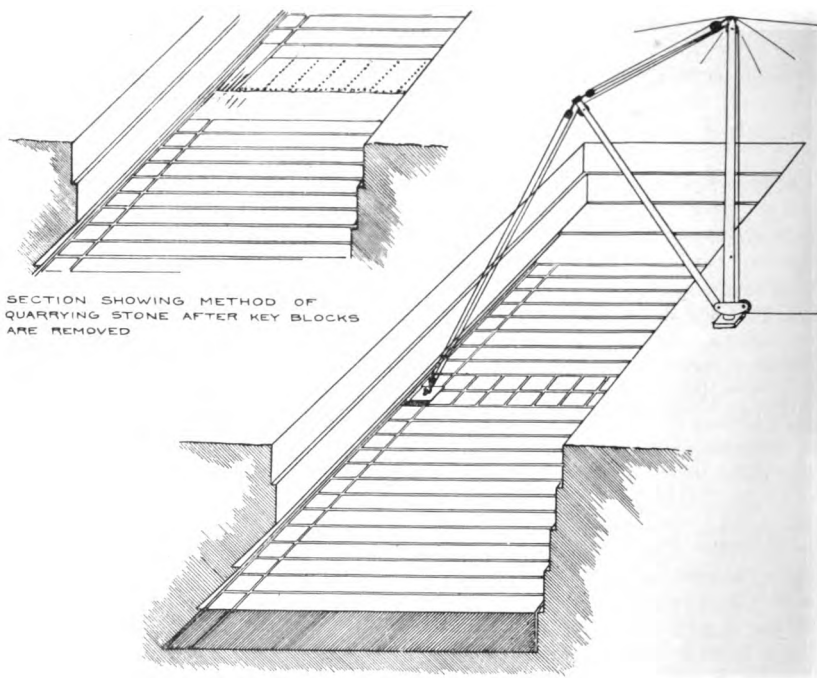


Diagram view of a new marble quarry, to illustrate method of opening described in the text

quarry articles, but reference to some of its distinctive features may be interesting, in view of the new standards of stone-cutting efficiency which it has established. This machine is a direct acting, double gang channeler, having the steels side by side in line and only  $10\frac{3}{4}$  inches apart. The two cylinders of this machine are within a single casting, having two bores fitted with replaceable linings  $6\frac{1}{2}$  inches in inside diameter. The two top heads also have replaceable linings, in which tail rods or extensions of the pistons run. The lower ends of the pistons carry the usual crossheads for holding the gangs, and these work under gibs, adjustable in all directions, for taking up wear and keeping the pistons in correct alignment within the cylinders.

This duplex chopping engine is fed down or hoisted by means of a large hollow feed screw centrally located between the cylinders. This screw works in an oil bath, so arranged that when the double cylinder and its adjustable mechanism travel up the standard, oil surrounds the screw and is forced up the inside and out through several small holes to the inside of the feed nut. This insures positive lubrication and long life to the feed screw and its nut.

The power for hoisting or feeding is applied to this screw direct from the feed engine, and is in no way connected with the track feed. At the front, and central with the cylinders, is a steam chest of unique design. This chest has the usual main and cut-off valves; the latter being worked from the crosshead in about the same manner as nearly all Sullivan channeler valve motions.

#### VALVE MOTION

Central with the steam chest is a single lever, controlled by the operator by a light wire handle, reached from either side of the chopping engine. This lever determines the position of a cone valve within the chest that, in turn, governs the alternation of the strokes of the chopping

engines. That is, one piston is made to strike while the other is lifting. Working in connection with this cone valve are the usual reverse valves for throwing the main valve.

This cone valve is so constructed that when its lever is vertical and the valves set for alternating, it causes both main valves to run, even if one or the other reverse valve should stop, as it would if a gang should become stuck in the cut.

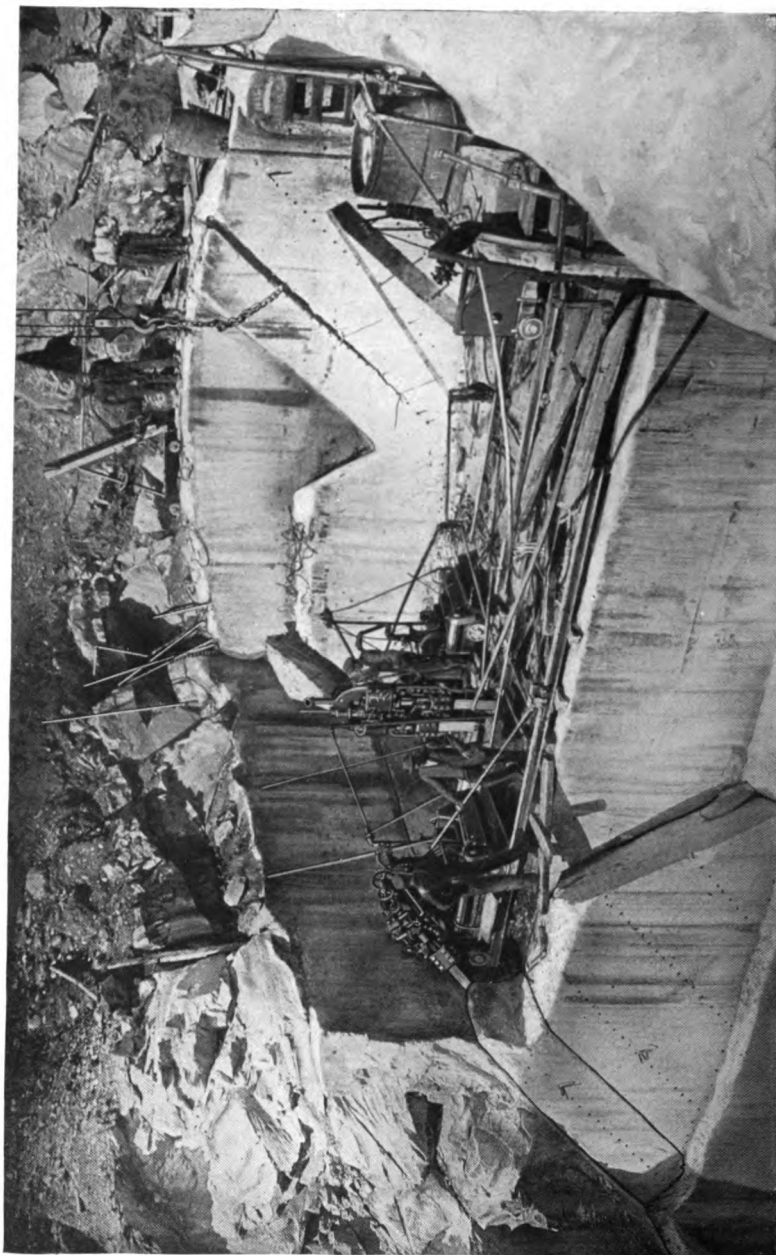
With valves arranged in this manner, it is almost impossible to stop the chopping engine. Each chopping engine may also be run separately, as is often necessary in starting a cut or working down a short high spot, or at the end of a cut. Again, should one of the chopping engines be disabled, its mate may be run as a single chopping engine.

This machine is showing a great gain in efficiency as well as in economy of operation over the single gang channeler, for the following reasons:

Vibration is greatly reduced, so that less care is required in track laying. There are fewer delays because of breakdowns, which are often caused by strain and crystallization set up by vibration.

In loose rock, the cut is not so apt to be blocked by raveling of the stone, because there is little shake and jar to the track. There is less friction of the gang in the cut, so that more power is applied to actual cutting. The two gangs mix mud better than one, and less time is given the mud to settle, because of the continuous steady action given by the improved valve gears. Quicker and easier control of the machine is given the operator, thus affording more time for actual channeling. The steels remain sharper for a longer time, because the work is divided between two gangs.

Aside from steam or air consumption, the expense of operating the machine is but a little more than that of operating a single gang channeler, while the amount of channeling done is more than double that of the single machine; some operators



A corner of the Clarendon Quarry, showing method of opening. Sullivan Corner Cutter in foreground, cutting a transverse cut made with the Sullivan Duplex Channeler to the right of it. In the rear, Sullivan Gadder, and Derrick lifting out a block

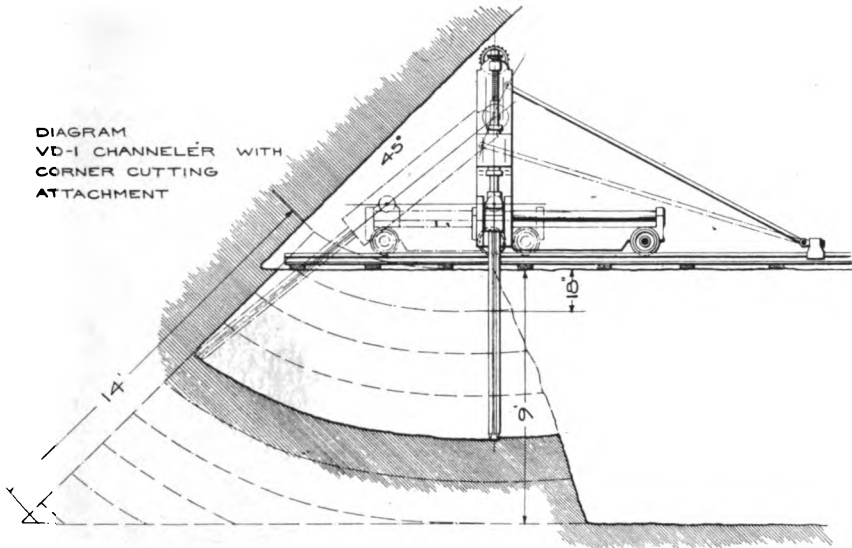


Diagram of Sullivan VD-1 Channeler with corner cutting attachment, working into a 45-degree tunnel cut. The dotted lines show position of machine and bits when cutting up to the wall

even claiming  $2\frac{1}{2}$  to three times as great a capacity.

The actual steam or air consumption is considerably less than for two single machines; this is due to the improved valve mechanism, and, in the case of steam, because there is less piping and smaller loss by radiation. The type of duplex channeler having its boiler directly on the frame of the machine, and carrying higher pressure, shows even greater steam economy.

At the Clarendon quarry, an ordinary day's work for a Sullivan "6½" channeler with single cutting head is 75 to 100 square feet, while the duplex has done as high as 219 square feet in ten hours, including moving on and off the cut. The duplex machine has frequently put in 45-degree tunnel cuts to a depth of 14 or 15 feet.

#### MOVING THE MACHINE

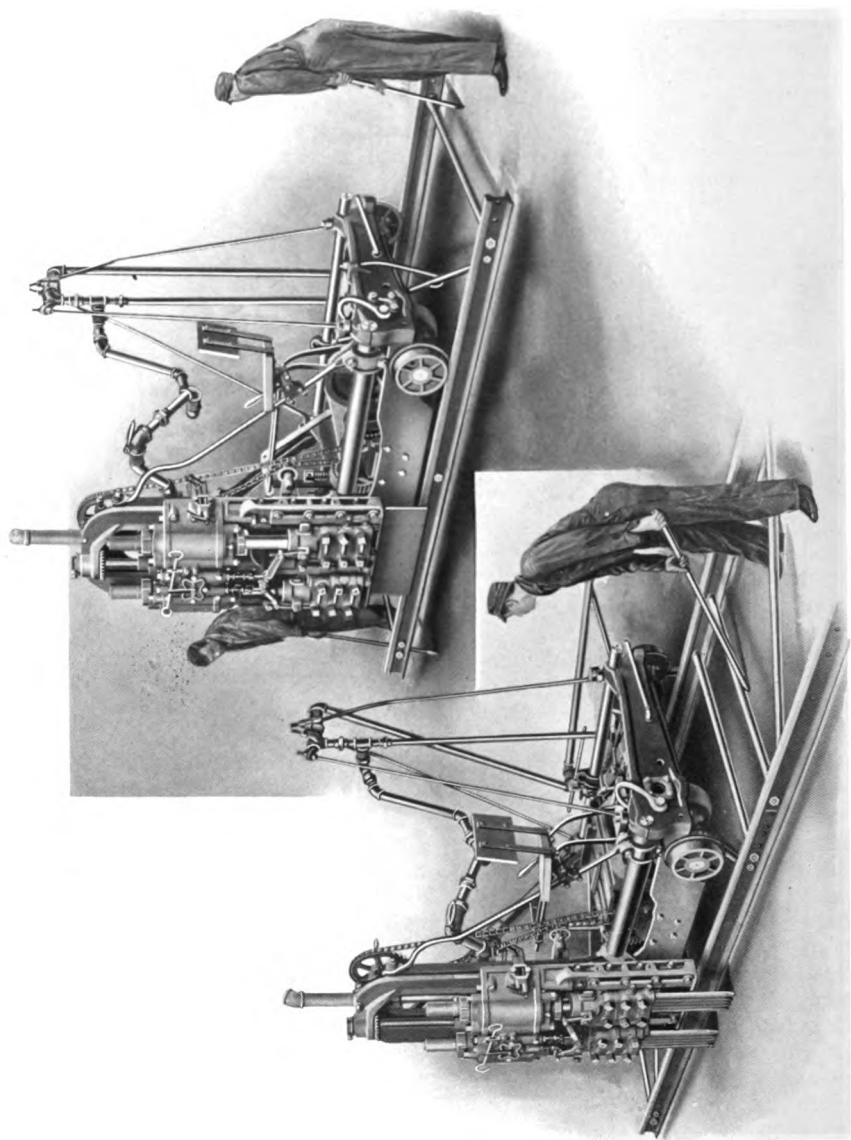
Special devices are provided for handling Sullivan duplex channelers rapidly and with minimum labor. The photograph on page 618 shows the machine

raised from the rails, to permit the track to be shifted beneath it. This is done by feeding down the chopping engine until the weight in front is taken by the drill steels. Jackscrews attached to the rear of the machine lift it on that side.

The duplex channeler can be turned around without the use of a derrick by the method shown on page 618. One of the jack-screws is screwed through a hole in the frame, at the center of gravity of the machine, and acts as a pivot on which to swing the machine. Binding hooks and clamps hold the track to the channeler frame, so that the track and machine are lifted and turn together. When the channeler and track are to be moved to another part of the quarry, the same method is used to lift the track with the machine, thus saving much time and labor.

#### CORNER CUTTING ATTACHMENT

From the manner of quarrying as outlined, it is evident that there is much transverse work as well as some corner cutting to be done, and that these cuts are



Sullivan Duplex Channeler. Upper view shows machine clamped to track and pivoted on central jack for turning around; lower view shows Channeler raised to permit track shifting

difficult to make, because they must run into a tunnel cut, sloping at an angle of 45 degrees.

The regular 6½ type of swivel head channeller is successfully used for this work up to a reasonable angle and depth. With the standard swiveled in line with the track, and the gang points set on a bevel, a transverse or corner cut may be made up to 25 degrees without much difficulty. When it becomes necessary to transverse into a tunnel cut of from 30 to 45 degrees, the work is slow and tedious.

The length of time required for this transverse work led Mr. McCormick, President of the Clarendon Quarry Company, to try to devise means of swinging the gang in such a manner as to keep the cutting points of the steel at right angles to the bottom of the cut, or nearly so. The sketch on page 617, shows how this is accomplished. The line of travel of the cutting points of the gang, as well as their relative position to the bottom of the cut are clearly shown. This swinging motion was accomplished by means of a connection rod between the top of the swiveling standard of the channeller and the front rail of the track. By loosening that part of the trunnion box clamp that binds the standard, the machine is free to travel back and forth a limited distance along the rails, thereby causing the gang points to describe an arc.

This worked very well for a time, but as the cut increased in depth and longer gangs were used, the steels were found to strike too far apart along the bottom of the cut; saw teeth would form and the cutting efficiency fell off rapidly.

By referring to the sketch, page 617, it will be seen that some feed-varying arrangement is needed to slow down the feed of the machine along the track, so that the gang points will not travel too fast along the bottom of the cut. It was evident that by combining this connection from the standard to the rail with certain change gear and brace features, designed for a special channeller for verti-

TABLE GIVING RATIO OF TRACK FEED TO TRAVEL OF GANG					
TRACK FEED FT. PER MIN.	CHANGE GEAR	DEPTH OF CUT		TRAVEL OF GANG FT. PER MIN.	
		FROM	TO	FROM	TO
7.37	24-T	TOP	27"	11.05	15.36
6.45	21-T	27"	4'-6"	13.46	16.77
5.53	18-T	4'-6"	6'-9"	14.33	17.25
4.6	15-T	6'-9"	9'	14.26	16.43
3.68	12-T	9'	14'	13.44	17.25

cal or wall cutting, a very useful machine could be made.

The result of this combination, as worked out by the Sullivan Machinery Co., is a machine so arranged that as the steel increases in length, the speed of travel of its points along the bottom of the cut may be varied so as to give the number of blows per foot best suited for the work. To best chip the average marble it is found that from 20 to 25 blows per foot along the cut is about right. This varies somewhat with the toughness of the stone.

The speed-changing mechanism and the improved hoist and feed of the chopping engine, as well as the adjustable back brace, are clearly shown by the cut on page 620.

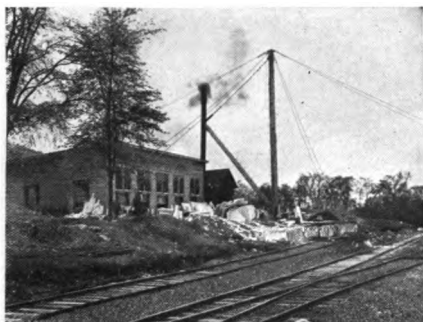
By means of a suitable set of change gears, the speed of travel of the gang points along the bottom of the cut is kept nearly uniform, regardless of the depth.

The machine starts its cut with a track feed reduced considerably below the regular speed. The top of the standard is held from advancing by means of its connection to the front rail. The point of the gang advances or swings faster than the machine travels along the track and this gang speed increases as the steel lengthens.

By using the change gears and slowing down the travel of the channeller on the track in proportion to the length of gang,



Sketch showing Sullivan Corner Channeler cutting out a corner in a quarry. The right wall slopes at an angle of 45 degrees, the left wall at 15 degrees.



Clarendon Mill and Yard

the proper working speed may be maintained.

The hoisting and feeding of the chopping engine are accomplished by power direct from the feed engine, and are in no way connected with the track feed. By the movement of a single lever the runner may feed his drill points against or from the rock, regardless of its angular position, or whether his machine is standing still or feeding along the track. This feature greatly lightens the work of the operator and increases his speed of handling the machine as well. This machine is arranged to permit swiveling backward as well as in line with the cut.

The standard or chopping engine may be used at either end of the machine as desired.

From the time of the first use of the steel gang channeler to the present, the Sullivan Class "6½" machine has been recognized as the standard channeler for marble. Nearly all tunnel and transverse work, the severest of all channeling, has been done by this Class "6½."

By using the attachment described in this article the wear and strain on the machine is greatly reduced, thereby prolonging its life and reducing the cost of repairs. The output of the quarry is greatly increased by the use of this mechanism, because the gang cuts much more rapidly at right angles to the work than when cutting with the points beveled or

at an incline. This machine has repeatedly put down cuts in two days that in the old way required two weeks.

This particular arrangement should appeal to the small quarry, where there is not enough corner and transverse work to keep one machine in constant use. By tightening up the standard in a vertical position, removing the long connection from the standard to the rail and putting on the regular side brace, the machine is quickly converted into a regular "6½" channeler.

#### FINISHING WORKS

The surface plant of the Clarendon Marble Company includes a four-gang sawmill, and eight additional gangs will soon be installed. Electric power is furnished for the saws, rubbing beds, etc., by the Clarendon Power Co. The authors are indebted to Mr. McCormick for assistance in preparing this article and in securing photographs.

#### THE DIAMOND DRILLMAN'S LOG DRILLING CAST-IRON

The Ward Shaft Pumping Association, Mr. Whitman Simms, superintendent, Virginia City, Nevada, has employed a Sullivan Diamond Drill extensively during the past year for explorations in the workings of old mines on the Comstock lode, which this firm is engaged in unwatering.

The drill is also used to tap old workings that are submerged, to drain the water. On one occasion a masonry bulkhead was drilled, and the core, when removed, was found to contain a six-foot length of solid cast-iron. The six-foot girder, plate or old stamp mill foundation block, whichever it was, caused no appreciable wear upon the diamonds. On the other side of the bulkhead, a flow of scalding water under 200 lbs. pressure was encountered, and this portion of the mine was drained through the diamond drill hole.



The west approach and mouth of the old Sand Patch Tunnel

### THE NEW SAND PATCH TUNNEL OF THE "B. & O."

CONSTRUCTION OF A SECOND BORE THROUGH THE ALLEGHENY SUMMIT ON THE MAIN LINE

In November of this year, the contractors will turn over to the operating department of the Baltimore and Ohio Railroad a new summit tunnel, at Sand Patch, in the Allegheny Mountains, which has been under construction since May, 1911. It is parallel, or nearly so, to the old one, and will do away with the congestion now existing at this point, and also cut down engine service. Three tracks will cross the summit, where now there is but one, and the mileage of the extra or helper engines will be reduced.

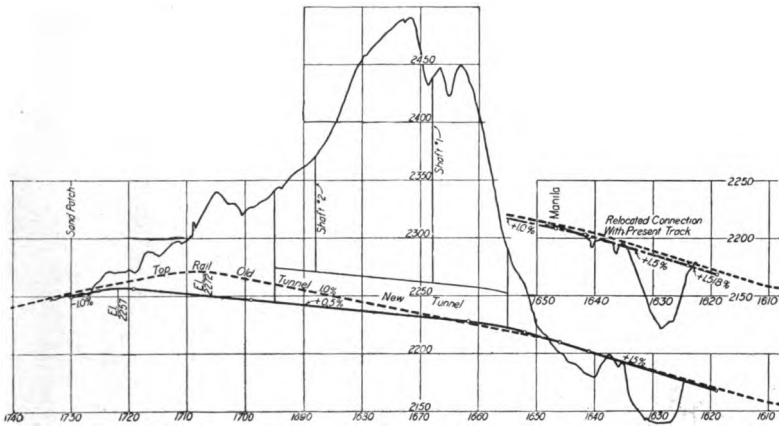
A heavy traffic of coal, steel, merchandise, cattle and grain is handled on this section.

#### PRESENT TUNNEL

The old Sand Patch Tunnel, completed in 1871, has a single track, and is 4,777 feet long. Seventeen years elapsed be-

tween its commencement and completion for traffic, although there were interruptions amounting to more than nine years. It was driven by the top heading plan, the maximum month's advance being quoted by Drinker as 43 feet.

This tunnel is on a one per cent grade, the summit point being 700 feet east of its west portal. The approach grades are 1.5 per cent on the east and one per cent on the west. There are now three tracks leading up to the tunnel from each side, one of them being used for down traffic and the other two for fast and slow trains, respectively, up the grade. The heavy freights require two helpers going either way; those eastbound requiring one helper engine from Confluence to Rockwood and two from Rockwood to the tunnel, 12 miles.





Sullivan Channeler, showing broken nature of the rock

contour drain high up above the cut and running it over the saddle. This work will be done this summer

#### EXCAVATING ROCK

The new cut has been made independently, so as not to interrupt traffic in the old narrow single-track approach. The drilling in the cut as well as in the tunnel has been done with an equipment of about 50 Sullivan UF-11, 3¼-inch, tappet valve rock drills, mounted on tripods or mining columns, as required. The rock formation is chiefly a stratified red sandstone, the beds dipping at about 90 degrees with the line of the tunnel and cut. The rock is broken, with vertical seams, and varies in hardness, as shown by the photographs on this page and the next, and for this reason the drill with tappet valve motion was selected. Some deep hole work has also been done with well drills.

Page 627 shows some of the Sullivan drills at work in the cut.

The broken rock is loaded by four steam shovels, two of 70-ton, one of 60 and one of 40-ton capacity, into four-yard dump cars, which are hauled by dinky locomotives.

#### CHANNELER AND QUARRY BARS

Owing to the depth of the cut, the engineers were anxious to make the wall next the hill as steep as would be consistent with safety, in order to reduce to the minimum the amount of excavation required.

To accomplish this purpose, it was desirable to disturb the rock wall as little as possible, particularly in view of the broken nature of the formation. To carry out this idea, a Sullivan heavy duty direct acting channeler, operated by steam from its own boiler, and two Sullivan



Sullivan Quarry Bar at work

quarry bars have been employed. The rock is drilled and blasted to within six feet of the engineer's wall lines, and the final wall cut is made with the channeler and quarry bars in eight-foot lifts. The rock outside the cut is then removed with light powder charges, so that the wall itself is not exposed to the jar of blasting.

A view of the channeler, starting work on the top bench, appears on page 624. The quarry bar is illustrated herewith. Two Sullivan  $3\frac{1}{4}$ -inch drills were mounted on it, and put in about 200 feet of 10-foot holes in ten hours. The holes were spaced nine inches apart. This apparatus required four attendants, i. e., a runner and a helper for each drill.

These methods have given good results and have saved a large amount of heavy excavation. A slide, totaling some 80,000 yards, occurred on this approach during March, but will not delay the completion of the tunnel to any extent. It took place on the south side, and had no effect on the channeler and quarry bar work.

The total excavation in the cut will be about 480,000 cubic yards.

In those parts of the work near the old tunnel and near the sides of the old approach cut, the plan of excavation has been such as to reduce as much as possible the shock of blasting in the direction of the tunnel and the cut, and to eliminate any danger from falls of rock within the tunnel or the cut. To accomplish the latter purpose a blasting inspector is stationed in a small building above the new tunnel portal, and is in communication by telephone with the signal operator in the tower at the Sand Patch station. Before each blast the foreman asks permission of the inspector, who communicates with the tower man, and if no train is due, has the operating track turned over to him by the tower man. The track then remains in the inspector's charge until he again notifies the tower man that the way is clear.

#### TUNNEL EXCAVATION

To carry on the tunnel excavation as rapidly as possible, two shafts were sunk: No. 1, 235 feet deep, 1,300 feet from the east portal, and No. 2, 135 feet deep, 2,000 feet west of No. 1, and 700 feet east of the west portal. This gave five headings to be driven simultaneously, including the east portal. The heavy overburden at the west approach prevented opening the west portal until the cut was made.

The tunnel is 31 feet wide in the clear, providing room for two tracks, 14 feet between centers. A semicircular arch springs from vertical side walls, at a point 11 feet above subgrade. The wall plates are 15 feet long and 16 feet above subgrade.

All headings were carried 9 x 16 feet in size. Those from the east portal and from shaft No. 1 were top headings, and the two from shaft No. 2 were begun as bottom headings, because the condition of the rock in the locality seemed to give promise of faster progress by this method. One of these headings, however, was later inclined upward and turned into a top heading.

## DRILL PRACTICE

The two shafts were completed about August 1, 1911, and work in all five headings began at nearly the same time.

The bore of the tunnel was completely holed through during December, after a progress averaging 225 feet per week of 13 ten-hour shifts, or 45 feet per heading. A round of 22 holes from 8 to 10 feet deep was usually employed in drilling the headings. The work was done with four Sullivan  $3\frac{1}{4}$  inch drills, mounted on two double-screw mining columns, and required about  $3\frac{1}{2}$  hours per round. The following table shows the monthly performance for each of the five headings.

The high record for a single month's work in any one heading was 296 feet, made in the west heading from shaft No. 1 during November. This gave an average of 5.3 feet per shift. The headings

all met, with respect to line and grade, in a most satisfactory manner.

## LIGHT DRILLING

In removing the bench, in trimming up the sides and roof of the tunnel, and in block holing and wall trimming in the approach cuts, light Sullivan drills on tripods and a number of Sullivan hand feed air hammer drills and stoping drills have accomplished a considerable saving in time and labor, as compared with hand work.

## TIMBERING

At first the rock was firm and strong, and little timbering was needed. As the work advanced, however, the roof became weaker and it has been necessary to timber the whole tunnel, on five foot centers, except for short distances at each portal, and near the two shafts, where the

## NEW SAND PATCH TUNNEL, 1911-1912

## CHART SHOWING HEADING PROGRESS

The headings are numbered from east to west

Heading No. 1	July	Aug.	Sept.	Oct.	Nov.	Dec.	Remarks
No. of shifts.....		24	56	57	13	.....	Date started, Aug. 14, 1911.
Footage (total).....		115	268	218	99	.....	Date of meeting with No. 2, Nov. 7, 1911.
Footage per shift...		4.8	4.8	3.8	7.6	.....	
Heading No. 2.							
No. of shifts.....		36	56	57	13	.....	Date started, Aug. 1, 1911.
Footage (total).....		76	224	220	80	.....	Date of meeting, November 7, 1911.
Footage per shift...		2.1	4.0	3.9	6.1	.....	
Heading No. 3.							
No. of shifts.....		36	56	57	56	22	Date started, Aug. 1, 1911.
Footage (total).....		69	223	245	296	146	Date of meeting with No. 4, Dec. 12, 1911.
Footage per shift...		1.9	4.0	4.3	5.3	6.6	
Heading No. 4.							
No. of shifts.....	36	38	56	57	56	22	Date started, July 12, 1911.
Footage (total).....	59	90	220	215	278	147	Date of meeting, Dec. 12, 1911.
Footage per shift...	1.6	2.4	3.9	3.8	5.0	6.7	
Heading No. 5.							
No. of shifts.....	37	38	56	57	25	.....	Date started, July 11, 1911.
Footage (total).....	64	78	191	220	141	.....	Completed to West Portal, Nov. 14, 1911.
Footage per shift...	1.7	2.1	3.4	3.9	5.8	.....	



Sullivan Tripod Drills on the west approach

centers are two or three feet apart. The tunnel has proved to be very dry, in spite of the fact that the old tunnel is quite wet. This is attributed to the fact that the old tunnel is above the new one and the inclination of the strata is such that the old tunnel serves to cut off the water and drain the new one. The beds are inclined at from 15 to 20 degrees with the horizontal, at right angles to the tunnel line.

#### BENCH REMOVAL

The 17-foot bench is drilled with Sullivan tripod drills and the spoil is removed with a 40-ton steam shovel, at a

monthly rate of 500 feet, and is now about 1,400 feet in from the east portal. A 60-ton shovel with a short boom replaced the 40-ton shovel on May 26, and even more rapid progress is being gained from this. A second 60-ton shovel will start on the bench from the west portal on July 15. The widening, out and timbering of the tunnel will be completed in the latter part of this month. The lining was begun about June 10. This lining, which is all of concrete, with the exception of a single ring of brick, starting at the 25-deg. point, is being placed by means of collapsible steel forms at the rate of 20 feet per shift.

## POWER PLANT

Air for the drills and shovels is furnished by two straight line, two stage, steam driven compressors of about 1,600 cubic feet capacity each, at 140 R. P. M., operated by six 100 H. P. boilers. The power house is near the west portal. Two six-inch air lines run over the mountain to serve the two shafts, and from shaft No. 1 to the east portal there is one six-inch main.

Electric power for lighting the tunnel is supplied by a 40-kw., 500-volt generator driven by an automatic engine. A machine shop adjoining the power house is

equipped with a steam hammer, lathes and other machinery.

The construction of the new Sand Patch Tunnel is under the direction of Mr. F. L. Stuart, chief engineer of the Baltimore & Ohio Railroad, with Mr. Paul Didier, principal assistant engineer. Mr. A. D. P. Janney is resident engineer at Meyersdale, in charge of construction. The work is being done under contract by the H. S. Kerbaugh Company of New York.

This article has been prepared with the assistance of Mr. Janney and the officers of the H. S. Kerbaugh Co., and is largely made up of extracts from an article in the *Engineering Record* of December 9, 1911.

## POWER CONSUMPTION OF COAL-CUTTING MACHINES

By G. W. THOMAS<sup>1</sup>

In selecting equipment for cutting coal, the mine operator must consider several factors, including first cost of machines and plant, cutting speed per machine, labor and power cost and the cost of repairs. Local conditions often render it difficult to forecast what operating expenses will amount to, and comparisons with records from other mines or other fields must be relied on to aid in selection.

The test reported below is of particular value, because in it especial efforts were made to secure accurate observations and to make the test run conform to actual working conditions.

It was conducted between December 13, 1911, and January 13, 1912, in Mine No. 2 of the Lumaghi Coal Company at Collinsville, Madison County, Illinois, upon a Sullivan "Continuous Cutter."

The test was to determine the cutting capacity and power consumption of the machine, as shown by measurements, time observations, and readings from a recording wattmeter.

## DESCRIPTION OF MACHINE

The Sullivan Continuous Cutter is mounted on a starting frame or pan, on which the machine travels in making its

rib or sumping cut, and which is detached when the cut across the face is begun. The machine is moved in all its operations in the working place on a continuous chain, which is engaged by drive sprockets, operated through feed gearing. The gearing is protected by a friction clutch, which is so loaded as to slip when the machine encounters obstructions in the coal.

The cut on page 628 shows the machine in the act of crossing the face, and the chain, by which it is manipulated. A shunt-wound motor of 30 horsepower is employed.

The machine was new and in good order.

## THE MINE, AND TEST CONDITIONS

The number 2 Lumaghi Mine was fully described in an article in *MINE AND QUARRY* for August, 1911. It works the No. 6 seam, which is eight feet high and practically level, although rolls or horsebacks occur in some localities. The coal varies in hardness in different parts of the mine, but is free from sulphur or other impurities. There is a good slate roof, so that close timbering is not required, and mining is done in the coal, as close as possible to the fire-clay bottom. The mine was formerly worked on the double entry plan, but the panel system is now in vogue.

<sup>1</sup>705 Olive St., St. Louis, Mo.

Two areas were assigned for the test, in one of which the coal was rated as "hard," in the other as "soft," and a territory of 24 rooms in each was set aside. The work was done in these rooms and in cross-cuts between the rooms. The places ranged from 18 to 45 feet in width, and averaged 31 feet. The Sullivan machine first cut in the "hard" territory, working three alternate days, single shift. The same procedure was followed in the "soft" territory, so that the test covered six shifts. Cutting in this way, over the territory described, enabled the loaders to keep enough rooms cleaned up so that a full day's cutting was ready for the machine every other day.

The readings and measurements were made by two observers, who checked each other's work and who made affidavit at the conclusion of the test as to the fairness of its conditions and the accuracy of the results contained in their reports.

#### TAKING THE READINGS

The observations taken in each working place included the time, at the beginning and end of each part of the operation; the power consumed, shown on a recording wattmeter of standard make; the average voltage, shown by a voltmeter in the room; the width of the room or break through and the depth of the under-

cut. After each room was completed, the wattmeter was reset at zero.

No readings were taken while the machine was moving on its truck, as the test had to do only with actual mining, and, since the length of the moves varied, observations began in each room with the unloading of the machine from its truck and ended when it was reloaded and ready to move to the next place. The following is a sample set of readings.

#### NO. 2 EAST STUB ENTRY OFF NO. 9 SOUTH

Operation	Time	Watt Hrs.
Unloading.....	2:00	0
Finished.....	2:06	150
Sumping.....	2:06	150
Finished.....	2:11	600
Cutting face.....	2:15	600
Finished.....	2:35	4300
Loading.....	2:50	4500

#### MEASUREMENTS AND READINGS

Average Voltage.....	225
Average Depth Cuts.....	73 in.
Width of room.....	24 feet
Watts per sq. ft.....	30.8

"Unloading" includes moving the machine into place against the right rib.

The table shown on the next page is a summary of the six reports covering the daily performance of the machine.

The machine had 24 loaders assigned to it, and "kept up the cutting" for all these men.

#### SUMMARY OF READINGS

Date	No. of Places	Face Feet	Average Depth, Inches	Square Feet	Actual Cutting Time Hrs. Min.	Total Watt Hours	Wts. per Sq. Ft.	Average Voltage
Dec. 13, 1911..	6	168' 10"	70.0	984.3	6 17	43475	44.1	191
Dec. 16, 1911..	6	186' 8"	72.1	1,121.5	6 26	48575	43.3	193
Dec. 19, 1911..	5	145' 2"	72.1	872.2	5 16	35600	40.8	191
Jan. 4, 1912...	5	149' 5"	73.1	910.1	6 22	38800	42.6	194
Jan. 5, 1912...	5	168' 9"	72.8	1,023.7	5 42	45600	44.5	185
Jan. 8, 1912...	5	181' 11"	70.2	1,064.2	6 52	51900	48.7	193
Total.....	32	1000' 9"	71.7	5,976.0	36 45	263950	44	191.1

TABLE OF TOTALS AND AVERAGES

Machine	Days	Hours Cutting	Places Cut	Face Feet	Average Depth, Inches	Total Sq. Ft. Cut	Total Tons Mined	Total Watt Hours	Average Voltage
Sullivan	6	36.45	32	1000.75	71.7	5976	1770.66	263,950	191.1

TABLE OF RATES

Machine	Face, Feet per Hour	Face Feet per Day	Sq. Ft. per Hour	Sq. Ft. per Day	Tons per Day	Watt Hours	
						Per Sq. Ft.	Per Ton
Sullivan	27.2	166.79	162.6	962.7	295.11	44.0	147.37

### COAL COST PER CUBIC YARD OF ROCK EXCAVATED ON THE CATSKILL AQUEDUCT

BY JOSEPH H. BROWN, JR., 30, CHURCH ST., NEW YORK

In an article written by Mr. Lucius I. Wightman, of the Ingersoll-Rand Company, and published in the Compressed Air Magazine for May, 1912, and elsewhere, certain statements are made in reference to the air compressors, installed at Firthcliffe, N. Y., by the Mason and Hanger Company, for driving the Moodna pressure

tunnel of the Catskill aqueduct, and in regard to their performance.

As these statements are incomplete and permit misleading inferences to be drawn, they are quoted below, with a statement of the facts, as secured from a study of the records, in parallel column for purposes of direct comparison.

From "Compressed Air," May, 1912

#### FEATURES OF THE STRAIGHT LINE COMPRESSOR

(The italics are ours, *Editor*, MINE AND QUARRY.)

This type of compressor, because of its simplicity, compactness, ease of transportation and installation, and "fool-proof" quality, will always find a place for development work in new properties. Some builders are manufacturing straight line compressors with high-duty features, such as compounded steam cylinders and even Corliss steam valves; and compounded air ends are so common as almost to call for no comment. But the difficulty of getting *economical regulation* under widely varying load, such as is characteristic of mining work, *without fly-wheel*, interferes with the economical refinement of such machines. Above 75 or 80 per cent load it may realize the fuel economy to be expected from steam com-

#### THE FACTS ARE AS FOLLOWS;

The Sullivan Machinery Company manufactures Corliss Tandem Compound Steam, Two Stage Air Compressors with full detaching Corliss valve gear on both high and low pressure steam cylinders, and it is to machines of this type that reference is made in the latter part of the opposite paragraph. The machines carry *heavy flywheels* — (on the 2,450 cu. ft. size the weight is 21,230 lbs.) — and may be operated as low as 10 per cent of the rated speed under the *complete control* of the Sullivan Automatic steam and air governor. The operation is at all times, as economical as that of cross compound Corliss machines of the same stroke, for the same economy is obtained from the two steam cylinders,

pounding and be economically self-regulating; below this limit it must either be *regulated by hand* or be left to blow off excess air through the safety valve, so that the double-tandem-compound compressor, whether either Meyer or Corliss steam valves, is but little more efficient on partial loads than a simple steam machine.

#### FROM "COMPRESSED AIR"

One of the contractors on the Catskill Aqueduct construction, New York, operated two different types of compressor plants on two sections of his work. One consisted of four double-tandem-compound Corliss-steam air compressors; the other comprised two double-cross-compound Corliss-steam air compressors, each with a capacity almost identical with that of each straight line unit in the other plant.

#### FROM "COMPRESSED AIR"

Both plants were operated under identical steam and air pressures and vacuum, and under *almost identical local conditions*.

whether they are placed side by side or end to end. A great number of Sullivan compressors of this type have been built, and are in successful and economical operation in mines, quarries and industrial plants and on contract work.

#### THE FACTS

The compressors referred to by Mr. Wightman as "double - tandem - compound" are Sullivan, Class WC, Tandem Compound Steam, Two Stage Air Compressors, each having a displacement capacity of 2,450 cu. ft. of free air per minute at 100 R. P. M. Four of these machines were installed in one plant on Section 1. The other plant, on Section 2, consisted of two cross compound steam, two stage compressors of the piston inlet type, with a displacement rating of 2,588 cu. ft. each at 125 R. P. M. The air pressure carried at the Sullivan plant was 110 lbs. and at the other plant 100 lbs. Both operated condensing and with 150 lbs. steam pressure.

Anthracite coal with forced draught was used at the Sullivan plant and bituminous coal with natural draught at the plant on Section 2.

#### THE FACTS

The conditions of load *were not identical*, nor anywhere near so. The Sullivan plant operated at full load nearly 24 hours a day, while the piston inlet machines only reached maximum capacity for a short time in each day.

Five shafts — four double heading and one single heading — or a total of *nine* working faces were supplied with air by the Sullivan plant. The installation of piston inlet machines only furnished air for two shafts, one of which was practically single heading, the south tunnel being only a few hundred feet long, making *three* working faces.

The air was used in drilling and pump-

## FROM "COMPRESSED AIR"

At the end of 16 months, the contractor *needed more air*; and to determine whether to buy straight line or duplex units for his addition, he went back over the fuel costs of his two plants for the previous 16 months.

## FROM "COMPRESSED AIR"

He found that his fuel cost for the double - tandem - compound compressor plant had been \$58,000 or \$5.92 per cu. ft. of free air for 16 months; while the coal cost at the double-cross-compound compressor plant had been \$15,000 or \$2.90 per cu. ft. of free air for 16 months.

ing, and also on Section 2, in hoisting; the use of air for the hoists, however, was intermittent, particularly at the single heading shaft, and was offset by the additional pumping by air on Section 1.

## THE FACTS

The investigation referred to by Mr. Wightman was *not* made by the contractor with the idea of deciding whether he should buy additional tandem or cross-compound machines. No more air was required on the work. The coal costs were looked into for the purpose of determining which was the cheaper type of fuel — anthracite or bituminous.

Combined with the boiler plant supplying the Sullivan compressors were the boilers which furnished steam for pumping and hoisting at the near-by shaft. In order to make a comparison of the compressor coal costs, a test was run by the contractor's engineers to obtain the cost of the coal not chargeable to the compressors, and this amount was found to be \$14.54 per 8-hour shift.

## THE FACTS

The total coal cost for 16 months at the power plant, where the Sullivan compressors were located, was \$56,615.00. Deducting the cost of the coal not chargeable to the compressors, viz: \$21,199.00, according to the contractor's records, leaves \$35,416.00 as the fuel cost of the four Sullivan Machines.

The total coal cost for 16 months of the two piston inlet machines was \$15,900.00.

Unfortunately no records were kept of the compressor revolutions per day, so that it is impossible to state just how much air was delivered by each plant, and it is manifestly incorrect to base the cost of air on the rated capacity of the compressors, because of the unequal conditions of load. The only way to show the comparative amount of work done, is to refer to the engineer's records of the yardage during the elapsed time. These figures are as follows:

SECTION 1 (Sullivan Compressors) 16 months, 178,250 cu. yards.

SECTION 2 (Piston Inlet Compressors) 16 months, 59,500 cu. yds.

During this period of 16 months the Sullivan Compressor plant, of less than twice the rated capacity of the piston inlet machines, had accomplished three times as much work, as shown by the engineer's records referred to above.

The cost of coal used in the compressor plants per yard of rock excavated was:

Sullivan.....	\$0.198
Piston Inlet.....	.267

or 34.8 per cent greater with the piston inlet compressors than with the Sullivan.

#### FROM "COMPRESSED AIR"

The figures showed that, had he been using the duplex compounds throughout, he would have saved \$29,596 in cost of coal alone during the 16-month period.

And the added saving in labor, oil, supplies and depreciation would probably have brought the total up to \$40,000, or a rate of \$30,000 saved a year.

#### FROM "COMPRESSED AIR"

*The contractor's order for added equipment was for duplex compressors.*

#### THE FACTS

Therefore, the contractor saved \$12,000.00 by using the four Sullivan Tandem Compound compressors, and would have saved \$4,000.00 more had his complete installation been of Sullivan make.

There was no difference in the comparative cost of labor, oil and supplies, and absolutely none in depreciation. Two of the Sullivan compressors and the two piston inlet machines are now installed under the same roof on a section of the New York City tunnel of the aqueduct now being driven by the same contractor. The other two Sullivan compressors are still at work on the original contract.

#### THE FACTS

*No new compressors have been needed or bought for either piece of work.*

All of the above facts can be verified by referring to the contractor's records and to the records of the engineers.



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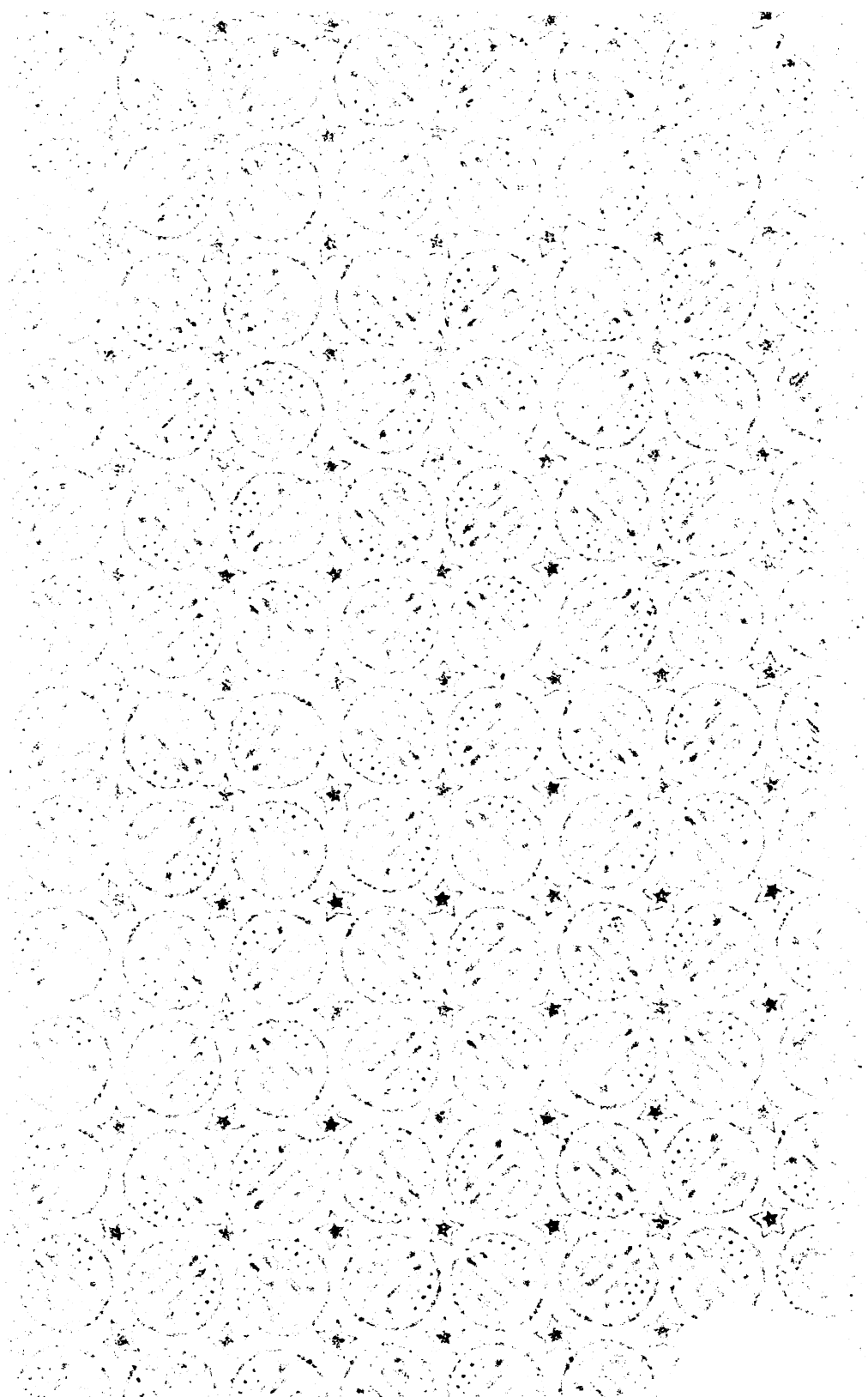












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